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HIGHWAY RESEARCH RECORD

Number 419

Public Transportation for Small and Medium-Sized Cities

4 reports

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Washington, D.C. 1972

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ISBN 0-309-02091-3
Library of Congress Catalog Card No. 72-12131
Price: $2.00
Available from
Highway Research Board
National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

CONTENTS

FOREWORD

Providing residents of small and medium-sized cities with public transportation services poses unique problems that have not been studied and analyzed to the depth of similar problems confronting the large metropolitan areas. The papers contained in this RECORD add significantly to the advancement of knowledge in this area. Three papers describe transit studies that were conducted for small cities and how the results of the studies were implemented. The fourth paper discusses a theoretical approach for using systems analysis for the design of suburban area transit service.

Heathington, Satterly, and Grecco discuss the research work done for the city of Lafayette, Indiana, where some 14 alternative systems were evaluated to establish priorities for public transportation. Many extra measures were taken during the transit planning study to keep the public and public officials adequately involved in all phases of the work. This led to an effective utilization of the research results and recommendations.

Steptoe and Poister describe the study approach and results of a transit demonstration project conducted in a low-density black residential area of Baton Rouge, Louisiana. The study included a survey of the physical arrangement of streets and land use, as well as socioeconomic characteristics of the residents. On the basis of the evaluation of the data a new system of main-line and shuttle service was recommended for the study area, which had almost no mass transit service. A comparative analysis of trip information for 2 years is being made to determine, in a quantitative way, to what degree the service has improved.

Dueker and Stoner present a report on the transit service improvements instituted in Iowa City. The paper describes the transit study that was conducted, the recommendations for new routes, estimated costs and patronage, and some of the operating experience and continuing studies. Before-and-after studies were conducted to determine attitudes and preferences regarding transit service.

Pratt and Schultz describe a method of using system design approaches for suburban area transit service. A solution readily usable with existing analyses programs is presented. The technique has the advantage for quickly identifying areas that have the potential for feasible transit service and for determining ranges of fares and headways.

PUBLIC TRANSPORTATION FOR SMALL URBAN AREAS

Kenneth W. Heathington, Gilbert T. Satterly, Jr., and William L. Grecco,
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Public transportation systems in small urban areas have been experiencing economic difficulties for quite some time. The requirements for transit planning for small urban areas may be somewhat different from those of large urban areas. The priorities for public transportation in small urban areas will normally be different from those established for the larger metropolitan areas. This study of an urban area with a population of more than 100,000 was performed to establish the priorities for public transportation. As a result of the priority analysis, 14 alternative systems were evaluated. A very close cooperation was maintained with the political structure through the entire study. This led to an effective utilization of the transit planning proposals.

• MANY public transit operations today are in serious trouble. Numerous factors have led to the decline of public transit, and the end result has been deterioration of service. As revenue from the fare box declined and costs of providing service increased, service was cut back through increased headways and reductions in route coverage. Rolling stock was not maintained properly and renewed when it should have been. The result of the reduced level of service was further reductions in patronage; in many small urban areas, the final result was a minimal level of service. The system uses old equipment to serve mainly, and perhaps exclusively, the well-known public transit captive riders—the old, the young, the poor, and the handicapped—who have no alternative method of transportation available to them.

Many privately owned transit properties have ceased operations and gone out of business, with the result that the community is left with no public transit service. The probability of reinstating a public transit system once it has ceased operation is extremely low. With this in mind, it is essential that communities that might wish to provide transit service not let the existing service (regardless of how poor) stop. In many areas, the community has recognized the need and has assumed the provision of public transit service.

In small urban areas public awareness of the need for public transit service many times is not so prevalent as it is in large metropolitan areas. In large metropolitan areas, many persons must be moved into and out of the central business district (CBD) and other concentrated areas of human activity each day. These large numbers of persons cannot be accommodated during the peak hours by the private automobile alone, and public transit is a necessity. However, this is not the situation in small urban areas. The requirements for, and justification of, public transit are quite different in small urban areas. Persons desiring to drive their private automobiles into the CBD of a small urban area can usually be accommodated on the street system, although with some congestion during certain times of the day. However, the length of the congestion period is relatively brief and can be tolerated.

In providing public transportation in small urban areas, one should not expect to "convert" large numbers of automobile drivers. The reduction in automobile use would not generally be such that the reduction in congestion or pollution would be significant.

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It would be helpful in building a case for public transportation if one could cite examples of large payoffs resulting from decreased automobile use, but this has not been the case in smaller urban areas.

In small urban areas, as in large ones, there are always persons who, because of age or economic status, do not have access to an automobile. These persons are dependent on public transportation. By providing public transit in the small urban area, we can meet the transportation needs of persons not having access to automobiles. As an added benefit, if the level of transit service is high enough, perhaps some automobile users could be induced to use the service. The result may be that the number of spaces required for on- and off-street parking in the CBD and at other locations in the city may be reduced.

In large metropolitan areas, a high level of transit service can be provided because of the large number of riders. In these areas, automobile level of service is low relative to that found in small urban areas. Thus, the level-of-service ratio for large urban areas can be quite good. It is not uncommon to find 3- to 5-minute headways for subway and bus service. However, in small urban areas these same headways cannot be economically attained; there are simply not enough riders.

Generally, there is a high level of service for the automobile in small urban areas. The travel time for automobiles is low, and parking is quite good relative to that found in large urban areas. By using traditional transit systems, one cannot provide a level-of-service ratio in small urban areas that will favorably compare with a level-of-service ratio for large metropolitan areas. Thus, using traditional bus transit systems, one finds it difficult to compete with the automobile in small urban areas. In these small urban areas, something other than the traditional fixed-route, fixed-schedule system will have to be employed if one hopes to attract the general public. Such concepts as demand-actuated systems (dial-a-bus) will have to be implemented to provide a level of service high enough to perhaps attract some automobile users to public transportation.

Much of the funding from the Urban Mass Transportation Administration (UMTA) has been oriented toward improving traditional transit systems, i.e., solving large urban area system problems. This is especially true for the funding under the capital grants program. The research and development program under UMTA has permitted some work in demand-actuated systems. However, these demonstration programs have not been as successful as desired. If there are going to be improvements in public transportation in small urban areas, local citizens will have to be permitted to solve their own problems using solutions peculiar to their area. The use of capital grant funds to depart from traditional transit systems for small urban areas would be a step in the right direction to overcome the problems of providing a high level of service. The restriction of capital grant funds to traditional transit systems for small urban areas simply places public transportation at a great disadvantage. A high level of service with traditional means can never be economically provided in small urban areas. There is a need for innovative transit planning for small urban areas; traditional methods will not suffice.

The following case study of public transit planning in Lafayette, Indiana, provides an illustration of the type of planning that can and should be done for small urban areas (1).

CASE STUDY

The privately owned bus system operating in the Greater Lafayette Area (GLA) decided to discontinue service in the spring of 1970. The cities of Lafayette and West Lafayette purchased the franchise and assets of the company and agreed to operate the bus service for approximately 1 year. At the time of the take-over by the two cities, a request was made to Purdue University to perform a bus transit study.

Because this study was to be performed for the local community, it provided a good opportunity for implementing many planning concepts for transit in small urban areas. As will be seen later, many of the planning concepts that have applications for small urban areas were implemented. A different approach to transit planning was attempted, and, from the results obtained and the public and political acceptance of the recommen-

dations, it is felt that this approach has been highly successful for at least one small urban community.

Greater Lafayette Area

The GLA is a small urban community composed of two core cities, Lafayette (founded in 1825) and West Lafayette (founded in 1845). The surrounding developing area is in Tippecanoe County, which was established in 1826. The GLA is located on Interstate 65 a third of the way from Indianapolis to Chicago.

The population of the Lafayette Standard Metropolitan Statistical Area (which includes all of Tippecanoe County) was 109,378 in 1970 and is projected to reach 150,000 by 1990 (2). It has been a rapidly growing area since 1940. Although this growth has been partly the result of the continuing expansion of Purdue University, which once was the dominant employer, most of the new and projected growth is, or will be, the result of continued and accelerating growth in industry and commerce.

About 42,000 people are employed in the area, 9,300 of them in local industry. In addition to being a market center for a rich agricultural hinterland, the GLA is becoming an important regional banking and financial center. Commercial areas and shopping centers are representative of those found in small midwestern communities.

History of Public Transportation in the Greater Lafayette Area

Public transportation has played a role in the development of the GLA for more than 100 years (3). The dawn of public transportation in the area came shortly after the Civil War, in 1869, with a system consisting of a mule-drawn railway known as the Ball Street Railway. The first "bus" was an omnibus, a horse-drawn Herdy Coach seating 12 passengers.

Planning and construction of the first really extensive public transportation system began in 1883, and the actual operation began in 1884.

Buses took over the entire public transportation service on May 12, 1940. The bus system continued to operate under various owners until July 1970. At that time the bus system came under public ownership.

One can see that public transportation has had a long history of operation in the GLA. As new technology and innovations came into being, they were incorporated into the public transportation system. At various times the system took on new dimensions both in technology and in areas served. Only in recent years had the owners used the profits for investment in other unrelated activities outside the GLA. This outside investment gradually led to the discontinuation of private ownership of the bus transit system.

Objectives of the Study

The general objective of the bus transit study was to evaluate the intra-urban bus transportation system within the GLA and make recommendations concerning public transportation in the GLA. The study specifically addressed itself to the following:

1. Transportation in perspective,
2. Existing system characteristics and performance,
3. General attitudes toward public transportation,
4. User attitudes toward public transportation,
5. Employee attitudes toward public transportation,
6. Political attitudes toward public transportation,
7. Guidelines for managerial operations for public transportation,
8. Guidelines for maintenance operations for public transportation,
9. Alternative systems for providing public transportation, and
10. Sources of financing public transportation.

By addressing the study to these 10 items, one could utilize some planning techniques that would have application to smaller urban areas and to small transit properties.

Transportation in Perspective

Public transportation is only one part of the overall transportation system, even in a small urban area. The airlines, railroads, trucks, buses, taxis, automobiles, and all other possible means of transportation in the area must be considered part of the total transportation system. The efficient coordination of all elements of this system, even in small urban areas, should be the ultimate concern of those responsible for planning and providing transportation. No element of transportation stands by itself. Each part of the transportation system provides certain functions that are difficult to duplicate by the other parts. A coordinated transportation system provides the balance necessary for efficient movement of goods and people within a small urban area as well as among urban areas. Each transportation subsystem should complement the other subsystems to promote effective utilization of resources. Unbalanced transportation systems can, at times, create problems for other activities within the urban area. One should have an understanding of the relation among the various urban systems in order to view transportation in a proper perspective.

This approach was used with regard to transportation in the GLA to present an argument to the power structure for the linkages that existed among all of the subsystems in the GLA. The discussion of the linkages involved in this area and portrayed in the study was intended to illustrate that transportation facilities in the GLA could not be viewed as a closed system. There are simply too many interrelations with various other subsystems to treat public or private transportation as a separate entity. It was strongly argued that viewing transportation as a closed system and making decisions on that premise would not lead to effective planning or utilization of resources of the GLA.

These linkages were discussed and presented to the decision-makers in a very elementary manner such that they could be easily understood by all. Some subsystems would be affected very little if bus service was discontinued. Other subsystems would be affected quite substantially.

Existing System Characteristics and Performance

Like any other transit study, this one was concerned with the system characteristics and performance of existing bus operations. An examination was made of the present bus system hardware, routes, schedules, fares, income, and expenses. An origin-destination survey of bus users was also conducted. Although this data collection is a traditional portion of a large transit study, it is also important for the study of small urban areas. System data must be collected and displayed in a format that is acceptable to the political structure. Even in small urban areas, it has been found that individuals in political office have little knowledge of how the system really operates. This is particularly true if the system has formerly been privately owned.

If the system has been under private ownership, it is often found, particularly in small transit properties, that no data have been collected relative to system characteristics and performance. In fact, in many smaller urban areas, there will be a total lack of information on which to base any decision regarding transit service. Frequently, the only data that are available are the total revenue. The revenue data may not even be available by routes. Frequently, as in the case of this particular study, one finds the system to be far more decrepit than is believed by the general public.

The bus system was found to be in a decrepit condition. The equipment had completely deteriorated and could not be rebuilt. The average age of the buses was more than 20 years. The bus system was barely able to maintain any semblance of operation and apparently had caused many of the riders to become discontented with the existing level of service. Ridership had steadily declined over the past few years. There had apparently been no effort on the part of management to promote public transportation in the GLA. Profits were invested in other unrelated activities. There was some question as to the potential of public transportation in the GLA.

Because of the poor condition of public transportation, for the past several years there had not been a viable alternative to the automobile. As a result of this (accompanied by continual ridership decline), there had been a change in trip-making charac-

terisitcs. Those persons no longer using the bus system were now making their trips by automobile. Most of the ridership was composed of captive riders. The riders really had no other alternative means of transportation for their trip-making. The majority of the riders were either elderly or very young. The largest group of riders was women, representing some 73.5 percent. A large portion of the ridership did not have drivers' licenses (62.3 percent), and a substantial number of the riders did not have a family automobile (37.5 percent). A large percentage of households (60.7 percent) had only one automobile. Very few, if any, of the riders used public transportation in the GLA because they desired to; they simply had no other means.

There were about 1,500 trips per day being made by bus transportation. There were less than 1,000 persons per day using the system.

The largest percentage of trips by purpose was for the work trip (42.8 percent). The largest group of riders was full-time employees. The CBD of Lafayette was the largest passenger-trip generator; Purdue University was the second major generator.

There were only two routes out of a total of four that had a reasonable amount of patronage. These two routes were also the only routes that had reasonable headways of 30 minutes. The bus system provided only limited area coverage. It did not provide bus transportation to some of the newer low-income housing units or to a substantial number of commercial activities. The level of service and area coverage had been greatly reduced over the years. In general, the bus system provided a very minimal level of transportation.

General Attitudes Toward Public Transportation

When examining any type of public service in small urban areas. We must keep in mind the importance of the attitudes of the general public. One might argue that in a small urban community the attitudes of the general public may have more influence on the political structure than in large urban areas. In small urban areas it is easy for an individual to have access to any portion of the political structure. To obtain an appointment with the local mayor, or any of the councilmen, is relatively easy. Most of the political forces are quite concerned about the attitudes of the general public, and many of them devote a substantial amount of their time to listening to suggestions from the general public.

Also, in small urban areas the news media have a strong influence on the community. The news media, whether newspapers, television, radio, or other, have a direct impact. Generally, the particular viewpoints of any given news medium reach a large percentage of the population of the area. This percentage is probably larger than could be reached by any one single news source in a large urban area. Thus, one can begin to see that in small urban areas public pressure can be great and can be exerted by various pressure groups. It will also be found that the political structure may be far more responsive to the desires of the general public in a small urban area than in the large cities.

One finds that, when a particular public service is needed in a small urban area, the citizens requiring the service may be few in number; however, on a per capita basis, they may represent a significant percentage of the population. One might argue that, on a per capita basis, the number of bus riders in the GLA would be equal to that of many other communities having a much larger population. Again, however, the absolute number of the riders is not large. Thus, when one begins to perform a planning study for public transportation in a smaller urban area, one must be well aware of the general public's attitudes and of whether this type of activity will be supported by the general public.

It is with the foregoing thoughts in mind that the attitudes of the general public were evaluated. To determine the attitudes toward bus transportation in the GLA, we administered an attitudinal survey as part of the Greater Lafayette Area Transportation and Development Study's origin and destination home-interview survey. Two questionnaires were administered to a total of 1,453 area residents. A total of 750 residents responded to the first questionnaire and 703 residents to the second questionnaire.

One of the objectives of this portion of the study was to determine the priority of a public bus system relative to other areas needing tax moneys in the GLA. The other

areas considered were public housing, streets and roads, public parks, pollution control, downtown railroad crossings, public welfare, police protection, and public schools. Another objective of the study was to determine the priorities of bus system characteristics that could exist in the GLA. Some of these characteristics were the assurance of getting a seat; longer hours of available service; more frequent service; more protection from weather at public bus stops; lower fare for passengers; shorter times spent traveling in bus; shorter walking distance to bus stops; and making a trip without changing buses.

Another objective of the study was to evaluate the present quality of bus service as viewed by the general public in the GLA. The respondents were asked to express an opinion on several statements, as follows: Bus stops are adequately marked; bus schedules are easy to find; buses are comfortable and pleasant to ride in; the insides of buses are clean, neat, and in good repair; there are enough shelters at bus stops; bus drivers are neat in appearance; bus drivers are often helpful and courteous; it is not too much trouble to transfer; buses go where I need to go; it is easy to find out which bus to take; buses make too many stops along the routes; buses are usually on schedule; and the bus hardly ever breaks down.

Another objective of the study was to develop a ranking of potential bus operators for the GLA. There were three options given: Lafayette, West Lafayette, and Tippecanoe County jointly; the cities of Lafayette and West Lafayette jointly; and a private bus company.

Another objective was to determine a fare structure that would be desirable to residents of the GLA. This included a determination of the amount that the fare should be as well as whether the fare should be based on distance traveled or one fixed fare regardless of distance. Various types of service such as a fixed-route, fixed-schedule system and door-to-door service were evaluated as to fare structure.

Another objective was to determine acceptable sources for financial support for a bus service in the GLA. Three choices were presented to the respondents: Bus service should pay for itself from fares charged users; bus service should be supported in part from fares and part from local taxes; and bus service should be free with the entire cost paid from local taxes.

Two psychological scaling techniques were used in the analysis of this portion of the study. The method of paired comparisons was used to develop relative rankings, and the semantic differential scaling technique was used to develop absolute rankings (4, 5).

The general attitude toward public transportation in the GLA was not a favorable one and at the most was one of indifference. When ranking public transportation relative to other areas that could compete for tax moneys, public transportation ranked very low.

Figure 1 shows the relative ranking by the general public of areas needing tax moneys. The method of paired comparisons was used to develop the ranking. It is seen from Figure 1 that bus service in the GLA had a very low priority relative to the other items. Figure 2 shows the relative ranking by the general public of bus system characteristics. More frequent service held the top priority relative to the other listed characteristics. The availability of seats on a bus transit system held the lowest priority.

Although the GLA residents had a low priority for public transportation, they were not opposed to continuing or expanding the service. They were generally in favor of the cities of Lafayette and West Lafayette operating a system. They slightly preferred this type of operation over that of a private firm. They preferred that the system be fully supported out of the fare box but would consider partially supporting the system from taxes. They were definitely opposed to free bus service.

From this portion of the study it was learned that, if one was to operate a bus transit service in the GLA and support any part of the system from tax moneys, a good public information program would be required. Considering the indifference toward public transportation in the GLA, one would have to be extremely careful in working out any proposed system. A misunderstanding by the public in general through the reception of insufficient or misleading information could have permanent harmful effects on public transportation in the GLA. However, if proper procedures are employed in developing a bus system, the public attitude may change to one of appreciation and understanding

for public transportation. This information was extremely helpful in the formulation of strategies to be utilized in the transit planning activities.

User Attitudes Toward Public Transportation

User attitudes toward public transportation were also evaluated in this case study. The data were taken during 1 day, Thursday, in November 1970 from the beginning of bus operation at 5:45 a.m. until the end of operation at 11:10 p.m. During the more than 17 hours of operation, more than 90 percent of the riders were surveyed aboard the buses. In addition, a mail-in questionnaire was given to each rider. A total of 913 mail-in questionnaires were given to bus riders. Of these questionnaires, 459 (approximately 51 percent) were completed and returned. The mail-in questionnaire was necessary because of interviewing time limitations on the bus and the need to obtain attitudes of users toward present and proposed bus systems. As with the general community, the users were asked to rank the same 9 community services competing for tax moneys as was done in the home-interview survey discussed previously. The method of evaluation was somewhat different because of the fact that the questionnaire had to be a self-administered one. The same 13 statements on the quality of the present bus service were also evaluated in the mail-in questionnaire. The bus users were asked who should operate the bus system in the GLA. They were asked to rank the fare structure, both for door-to-door service and for fixed-route, fixed-schedule service. They were also asked to indicate their preferences for financial support.

As one would expect, the user is quite concerned about the continuation of public transportation in the GLA. As can be seen from Table 1, the users place a high priority on continuing the bus system. In other respects it is interesting to note that their philosophy toward other aspects of bus service is very similar to that of the general public. The bus users also desire that the bus system be supported from the fare box. They are also in agreement that the bus system should be operated by the cities of Lafayette and West Lafayette. Both the users and the general public would seem to be receptive to a bus service that would provide door-to-door service for an additional fare. With the exception of priorities placed on continuing bus service, there was very little difference between users' attitudes and the general public's attitudes toward public transportation in the GLA.

Employee Attitudes Toward Public Transportation

In implementing a new system with new innovations, one will find that employee attitudes and cooperation will have a tremendous impact on the success of a small transit property. Thus, it was desirable to learn of any difficulties that might result from the introduction of innovations in the bus system in the GLA. The Clinical Psychology Department of Purdue University agreed to undertake this portion of the study. Employees were all brought together for a group discussion, and the session was conducted by a department faculty member. After the group session, the results were analyzed and reported.

It was found that employee attitudes toward what would promote public transportation in the GLA were generally in disagreement with those of professional planners. A need for education and training of these employees in the concepts of public transportation was shown to exist. Many of the attitudes that the employees had were not compatible with good operations. However, there appeared to be few undesirable conditions existing that could not be overcome through proper training and education.

Political Attitudes Toward Public Transportation

This case study evaluated alternative plans to provide, operate, and maintain a viable, coordinated bus transportation system responsive to the needs of the inhabitants of the GLA. As part of the evaluation process, the study identified social, political, economic, and physical factors that needed consideration. A basic consideration in the planning of any type of public system for a community is the determination of the goals and objectives of the area as viewed by the political structure. The determination

Figure 1. Community priorities for allocating tax moneys in the GLA.

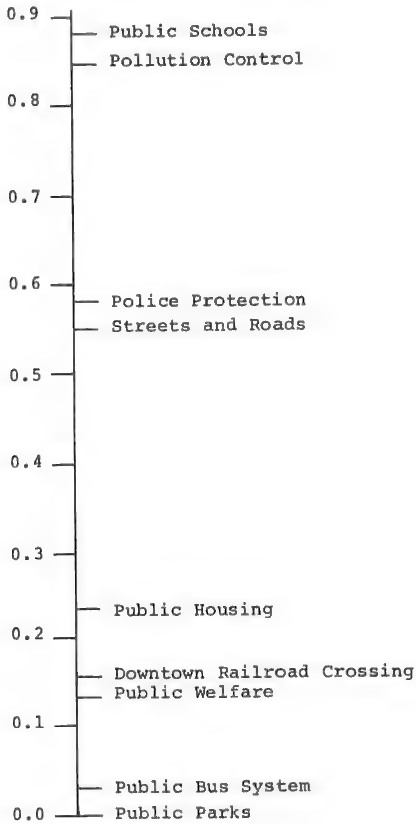

Figure 2. Relative ranking of bus system characteristics by residents of the GLA.

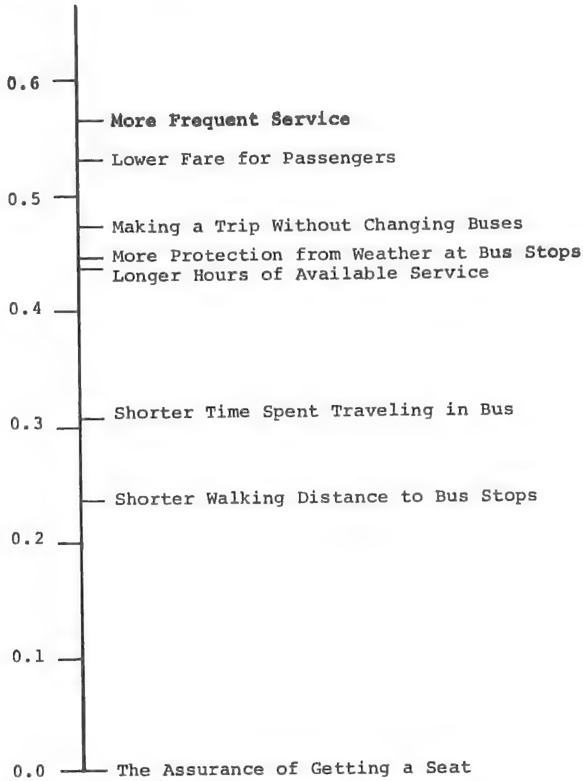

Table 1. Bus users' ranking of community priorities for allocation of tax moneys.

Item	Mean Order of Ranking	Bus User Priority Ranking	General Community Priority Ranking[a]
Police protection	3.05	1	3
Public bus system	3.49	2	8
Public schools	3.58	3	1
Pollution control	4.02	4	2
Streets and roads	5.09	5	4
Public housing	5.17	6	5
Welfare	6.08	7	7
Downtown railroad crossings	6.40	8	6
Public parks	6.70	9	9

Note: The smaller the mean scale value is, the higher the position of the item on the priority list is.

[a]Taken from Figure 1.

of community goals and objectives toward public transportation was a major endeavor. It first required the identification of the individuals who composed the political power structure of the community. A faculty member of the Political Science Department of Purdue University assisted in this portion of the study.

In this study, a questionnaire was used to assess the social, political, economic, and physical factors and to assist in establishing the transportation goals and objectives as they relate to public transportation. The questionnaire was administered to members of the political power structure as well as to persons who were expected, in their own appraisals, to reflect the ideas of those in the power structure. An analysis of the survey of the political structure indicated that it was feasible to have a public transportation system in the GLA. The political structure seemed to recognize the persons in the community who would be most drastically affected by discontinuance of transit service. The leaders seem to view public transportation in the GLA as providing a service to the people rather than as being a business enterprise. It was discovered that there would be some political opposition to continuing bus operations in the GLA, particularly the expansion of present operations.

Guidelines for Managerial Operations for Public Transportation

It was essential that alternative types of organizations for providing area-wide public transportation services be presented to the community. The advantages and disadvantages of each vary in accordance with local conditions. The question of what form a public transportation organization should take is further complicated when the service area extends over several governmental divisions. In addition, the various types of organizations must conform to the regulations provided by state and local governments. The possibilities for management organizations are numerous because many are slight variations of others. The study was centered on the three major options: private ownership, municipal ownership, and public authority.

There are many ways in which a public bus system could operate in the GLA. Several of these ways were explored. A transit authority having a certain structure could offer the more promising manner in which to operate a bus system in the GLA. The planning advantages were that such an authority would offer a method of operating over several political boundaries and the ability to raise sources of revenue through taxation. This method of operation was found to be a more promising form of operation when viewed at the local, state, and federal levels. A transit authority also provided a better financial basis of operation. The Urban Transportation Act of 1965 enacted in Indiana provided the enabling legislation for the establishment of a transit authority with broad powers.

Guidelines for Maintenance Operations for Public Transportation

Efforts of researching, planning, and organizing a successful bus system would be incomplete unless the system included an effective maintenance program. Many managers and supervisory personnel today give the area of maintenance only a passing glimpse in their duties of operating an efficient organization. One should initiate a good maintenance program at the beginning of an organization's operations and continue it throughout the life of the operation. Poor maintenance was one of the contributing factors in the decline of the bus service in the GLA. Maintenance was allowed to deteriorate. As a result, the bus rider's confidence in the system decreased when breakdowns became more frequent as unreliable buses were kept in service. The main objective of this portion of the case study was to establish the basic elements of an effective maintenance program for a bus system operating in the GLA.

A detailed program was outlined, and the computer software was developed for the effective utilization of the proposed program.

Alternative Systems for Providing Public Transportation

The existing system characteristics and performance, composition of ridership, and user and public attitudes toward public transportation would not be sufficient in themselves for a transit study. One has to evaluate the various alternative systems composed

of combinations of different types of equipment, routes, and schedules. The level of service provided with the cost of each proposed system was estimated and reported in the study. Some 14 alternative plans for providing public transportation in the GLA were developed and analyzed. These alternatives ranged from the same routes and schedules as in the present system with new equipment to an expanded system operating on a number of new routes providing extended coverage with reduced headways.

Some of the alternatives provided for fixed-route, fixed-schedule operation during the peak hours with demand-responsive service during the off-peak periods. These alternatives did not exhaust all possibilities. One could combine various parts of the 14 alternatives as to routes, schedules, and/or types of equipment and formulate additional alternatives.

Tables 2 and 3 give the 14 alternatives and the cost associated with each one for this particular case study.

The basic assumptions concerning levels of service used in the development of bus system alternatives for the GLA were as follows: One level of service was to continue the same area of coverage with the same routes and the same headways; a higher level of service was to continue the same area of coverage but to reduce the headways on the present routes; a third level of service was to extend the area of coverage so that all people in the GLA would have access to public transportation and at the same time reduce at least some, if not all, of the route headways from those on the existing system. There were four or five alternatives analyzed for each of these levels of service, using various sizes of buses and combinations of fixed-route, fixed-schedule service and demand-responsive service. All of the alternatives reviewed require a substantial amount of capital investment for a small urban area, some substantially more than others.

The total investment for each of the alternatives varied from about $250,000 to approximately $500,000, with a total annual cost (capital and operating) ranging from about $207,000 to approximately $407,000. By using the present number of passengers, about 430,000 per year, we found that the fixed-schedule fare necessary to meet the total cost of the system varied from 48 cents to 91 cents per ride. If the capital costs were assumed to be subsidized from general tax moneys, the fixed-schedule fare required to meet the operating expenses of the system varied from about 40 cents to 74 cents. By using the maximum number of passengers that the various systems can accommodate and using a peak-period load factor of 1.5, we found that the fixed-schedule or base-period fare would vary from about 17 cents to 34 cents to meet total costs and 13 cents to 28 cents per ride if only the operating costs would be met from the fare box.

Sources of Financing Public Transportation

The sources of financial support of public transportation are varied and dependent on the type of ownership of the transit operation. These sources of financial support will also vary from one state to another. Many sources that are available to a publicly owned transit operation are not available to a privately owned transit company. Various states permit various ways of obtaining sources outside of the fare box for transit operations. There is a wide variance in these regulations from one state to another.

Financial support of privately owned transit companies for capital improvements and operating costs is primarily from fare-box revenues. Capital improvements for privately owned transit companies can be financed through equity capital stocks, bonds, equipment trust obligations, and/or long-term leases. If a city desires to encourage a private company to provide transit service, it may sell municipal bonds or obtain a federal grant for capital improvements, construct transit facilities and purchase equipment, and then lease the facilities and equipment to the private operator. However, the trend since World War II is for public agencies to acquire public transportation systems from privately owned companies because private entrepreneurs have not been able to make a reasonable profit.

Financial support of publicly owned transit may be entirely from fare-box revenues or partially or wholly supported by subsidies from tax moneys in Indiana. Capital im-

Table 2. Summary of alternatives.

Alternative	Total Initial Investment[a] (dollars)	Annual Capital Recovery Cost (dollars)	Annual Operational Cost (dollars)	Total Annual Cost (dollars)	Level of Service[b]	Number and Type of Bus[c]
1	251,452	34,700	172,600	207,300	I	6M, 1XL
2	278,148	36,900	177,400	214,300	I	2L, 4M, 1XL
3	304,844	39,100	182,200	221,300	I	4L, 2M, 1XL
4	331,540	41,500	187,200	228,700	I	6L, 1XL
5[d]	251,452	34,700	206,700	241,400	I	6M, 1XL
6[d]	312,492	40,100	234,700	274,800	I	6M, 7S, 1XL
7[d]	392,580	63,800	223,400	287,200	I	6L, 7S, 1XL
8[d]	334,684	52,400	259,300	311,700	II	12M, 1XL
9	334,684	52,400	286,400	338,800	II	12M, 1XL
10[d]	395,724	74,900	269,000	343,900	II	12M, 7S, 1XL
11[d]	316,460	71,600	335,300	406,900	II	17S, 1XL
12	358,760	45,300	208,800	254,100	III	7L, 1XL
13	413,200	54,200	261,600	315,800	III	9L, 1XL
14	494,860	66,500	308,900	375,400	IIIA	12L, 1XL

[a]Includes $25,000 for 5 acres of land and $105,000 for facilities. Also includes buses, fare boxes, and radios.
[b]I = present routes and schedules; II = present routes and reduced headways; III = extension of area of coverage; and IIIA = extension of area of coverage and reduced headways.
[c]XL = 45-passenger bus; L = 33-passenger bus; M = 18- to 23-passenger bus; and S = 12-passenger bus.
[d]Demand-responsive during off-peak hours. Demand-responsive fares are assumed to be $0.10 higher than the peak-hour or base fare for fixed-route, fixed-schedule service.

Table 3. Cost data for alternatives.

Alternative	Total Present Annual Passengers	Using Present Number of Passengers, Fixed-Schedule Fare to Equal (dollars)		Annual Maximum Number of Passengers for System With 1.5 Load Factor During Peak[a]	Using Maximum Number of Passengers, Fixed-Schedule Fare to Equal (dollars)		Increase in Passengers Over Present (percent)
		Total Cost	Operational Cost		Total Cost	Operational Cost	
1	428,000	0.48	0.40	715,000	0.29	0.24	75
2	428,000	0.50	0.41	665,000	0.32	0.26	55
3	428,000	0.52	0.43	865,000	0.26	0.21	102
4	428,000	0.53	0.44	1,075,000	0.21	0.19	151
5[a]	428,000	0.52	0.44	715,000	0.29	0.24	75
6[a]	428,000	0.60	0.51	715,000	0.34	0.28	75
7[a]	428,000	0.63	0.48	1,075,000	0.22	0.16	151
8[a]	428,000	0.69	0.57	1,430,000	0.17	0.13	234
9	428,000	0.79	0.67	1,430,000	0.24	0.20	234
10[a]	428,000	0.76	0.59	1,430,000	0.19	0.14	234
11[a]	428,000	0.91	0.74	1,100,000	0.32	0.26	157
12	428,000	0.59	0.49	1,200,000	0.21	0.17	180
13	428,000	0.74	0.61	1,430,000	0.22	0.18	234
14	428,000	0.88	0.72	2,150,000	0.17	0.14	402

[a]Total computed by assuming that all buses during peak are loaded to 1.5-seat capacity and off-peak demand adjusted by factor obtained from ratio of present peak-hour demand to calculated demand.

provement funds can be obtained by sale of bonds, borrowing, use of equipment trust obligations, and/or receiving capital improvement grants for facilities and equipment from the federal government through the Urban Mass Transportation Administration of the Department of Transportation.

Recommendations in the Case Study

In performing any study, one has to eventually make some recommendations. One should be extremely careful that the recommendations made are both politically and economically feasible. Perhaps those two considerations have more impact on implementation in a small urban area than any others one might give.

The decision to continue or discontinue bus service in the GLA is a political one. The study team asserted that the systems analyst is not the decision-maker. He should present the various alternatives, including impacts and consequences as determined in the analysis and evaluation of each alternative, with recommendations to the decision-maker. A substantial amount of attitudinal analysis along with various alternatives indicating the cost and level of service associated with each was reported. These analyses should have enabled the political structure in the GLA to arrive at a decision to continue or discontinue bus service. Therefore, it was not the study team that made the decision as to whether public transportation should continue in the GLA.

The choice of the level of service, if the bus system was to be continued, was also a political one. Again, detailed analyses were performed for each level of service. The risks involved in providing public transportation were high. The chances of a financial success were remote. Therefore, a bus service should have been viewed like other public service systems that are not expected to be financially profitable. There were benefits to be derived from public transportation that were not dollar benefits, the same as with parks and recreation, police and fire protection, libraries, low-income housing, garbage collection, street cleaning, and insect control. Thus, the decision to have a bus system, with an associated level of service, was really a political one. From the analyses of the study, the political decision-makers had an estimate of the amount of money that might be required from tax monies. The decision to use tax moneys for a system such as this one should reside with the political decision-makers of the GLA. There were some specific recommendations that were made contingent on the continuation of bus service. These were of a technical nature and could affect the operations of the transit systems.

Specific Recommendations

The following recommendations were taken from the Greater Lafayette Area Bus Transit Study (1):

1. A decision should be made as to whether to continue bus service in the GLA immediately. The present operations only add to the deterioration of ridership.

2. If bus service is to be continued, the plans for continuing service should be on a long-term basis. The decision should be made to continue a system for at least 10 years. A decision should not be made for a temporary system. There is a reason for this recommendation. First of all, the system has declined over several years; it will take several years to bring the level of ridership up to previous levels. It may take several years for people to change their travel habits and to change their mode of travel. A good transit system has to be in operation for a substantial amount of time for people to make a decision not to purchase the second or third car or perhaps to sell some of the cars that they now operate. It should not be expected that one would see any great increase in the number of riders in less than 3 to 5 years. A year of operation will probably not be indicative of the long-run potential of public transportation in the GLA. If the decision is made to continue bus service, the decision should be made to continue it for an indefinite period of time.

3. If bus service is to be continued, it should be continued with the thought in mind that it will not be financially profitable. It may be a profitable venture, but the risk involved will be great. A 25 to 50 percent subsidization of total costs of the bus system

may be required. It will be difficult, if not impossible, for revenue from the fare box to pay for the entire system. An increase in fares will make it difficult to have an increase in ridership. There has to be a substantial increase in ridership for the revenue from the fare box to support the entire system.

4. If the decision is made to continue the bus system, full support should be given by the cities of Lafayette and West Lafayette and Tippecanoe County. They should back the bus system with financial aid and with other political decisions that can materially affect the operation within the GLA.

5. If a bus system is to continue in the GLA, it should do so under a transit authority. The transit authority should have an advisory committee of political appointees, but the manager and the employees of the transit authority should be under a merit system of operation. The transit authority should be given wide leeway in making decisions that will affect service in the GLA. The transit authority should be totally responsible for all operations and management of the bus system. The transit authority should be given taxing power.

6. If a bus system is to be continued, it is recommended that strong considerations be given to operating a fixed-route, fixed-schedule system in the peak periods. Headways should be reduced. A demand-actuated system should be employed in the off-peak periods.

7. Completely new equipment and facilities should be provided. Little equipment, if any, can be salvaged from the present operation.

8. All available outside sources for financing should be explored. Every attempt should be made to obtain funds for this system outside of those from the fare box.

9. During the interim period of purchasing new equipment, creating a transit authority, obtaining outside support, etc., a continual planning process should be going on. This planning group should be developing scheduling procedures for the dispatchers for the demand-actuated portion of the system; it should be examining more closely the exact routes to be employed with a better scheduling of transfers in the downtown area, etc. The entire operation should be planned and programmed by the time new equipment is available.

10. Charter service should be greatly expanded. A substantial amount of effort should be put into utilizing the charter franchise to its greatest extent because of the profitable characteristics of charter service.

11. It is desirable to obtain long-term contracts with the public school systems in the GLA to provide bus transportation.

IMPLEMENTATION OF RECOMMENDATIONS

There were many steps taken during and after completion of the study to ensure that the recommendations made were actually implemented. It was the intention of the study team to ensure that all of the information gained from this study would be utilized for transit planning in the GLA. The study team was as much interested in implementation as it was in transit planning. Therefore, there were many extra measures taken during the study that are not normally found in a transit planning study.

It was felt from the very beginning that the political power structure should be kept adequately informed throughout the study. As various portions of the analysis were completed, the political power structure representing three political divisions of the area was called together into a group, and formal presentations were made to these people. During this time, reactions were reviewed as to the way in which the study was proceeding. Comments were solicited in order to help guide further analysis within the study. Suggestions were sincerely taken, and a conscientious effort was made to incorporate all of them into the planning activity.

It was realized (when the results began to be obtained from the analysis of the attitudes of the general public) that public transportation was not a popular item within the GLA. It was then decided that certain information must be furnished to the general public that would perhaps change attitudes toward public transportation. Because the general public has an indifferent attitude toward public transportation, the measures taken must be very well thought out. If these measures have the wrong impact, the attitudes could become negative within the community.

It was decided that several approaches would be developed to provide information to the general public through the various news media sources. In the GLA there are two local newspapers, three radio stations, and one television station. All of the news media were utilized during this interim period. The first step was to present brief items to the general public on what other people throughout the United States and Canada were doing with problems in public transportation for small urban areas. Other cities such as Mansfield, Ohio; Toronto, Ontario; and Ann Arbor, Michigan, were reviewed in various articles in the newspaper and on television and radio to indicate what could be done to solve the public transportation problems of small urban areas. This news coverage was not a one-time occurrence. It consisted of several articles over a quite lengthy span of time. Care was taken not to discuss any of the recommendations that might be made for the Lafayette area.

During this same period, there was contact made with many civic and professional organizations. Organizations such as the Chamber of Commerce, the Optimist Club, and Society of Professional Engineers were given presentations on all aspects of public transportation for small urban areas. These groups were informed as to the ongoing study and the results that were being obtained from the analysis before it was in completed form. They were instructed in how other cities were solving their problems.

The final presentation was made to the political divisions in May 1971, with the recommendations as outlined here. In approximately 1 month, the political structure made the decision to continue public transportation in the GLA. The two city councils of Lafayette and West Lafayette passed an ordinance establishing a transit authority. However, Tippecanoe County refused to participate in the enterprise. A transit authority was formed during the summer of 1971 and became official as of September 1, 1971. A 7-man board was appointed.

The study team made presentations to the transit authority, outlining to the 7 members all of the information that had been given to the political power structure. The transit authority immediately began a program of its own to keep the people, as well as the political power structure, informed. The authority also began a program to indicate to the people that something was actually begin accomplished. Several bus manufacturers were immediately contacted and asked to furnish demonstrator buses to the Greater Lafayette Public Transportation Corporation. These buses were brought in one at a time and were kept for several days in the community. The buses were demonstrated in the downtown area and at various shopping centers. GLA residents were asked to board and ride the buses and inspect them at their convenience. The buses were then put on various routes in the city, which allowed the employees to become familiar with the different types of equipment that was now available for bus transit service. Considerable effort was made to ensure adequate news coverage by all the media of each bus that came in. During this same time, the transit board established a tax base for the coming year. The tax levy went through all of the appropriate review processes as required by state law without any objection from any of the citizens of the GLA.

During this period, members of the study team were preparing the capital grant application for the matching funds for building new facilities and acquiring new equipment. Each time that something new was performed with the transit authority, an attempt was made to ensure adequate news media coverage.

During November 1971, there was a change of administrations in both Lafayette and West Lafayette. This, of course, required a completely new round of information transfer to the new political structure.

It is felt that almost all of the recommendations have been implemented or are in the process of being carried out. Implementation of the recommendations has been successful largely because of the program to inform the public in a meaningful way of the problems and solutions of public transportation in the GLA. It has also been essential that all of the political structure of the political divisions participating in the project be kept informed of all of the things that have been going on. These two items are perhaps the most important of all of the energies that have gone into transit planning for this small urban community. The professional expertise has very little to do with the ability to implement recommendations. The transit planner must understand that, if his plans are to be accepted and implemented, he must be willing to become politically oriented

from the general public's point of view as well as from that of the public office-holder. Without the cooperation of the power structure in a small community, one finds it almost impossible to implement a workable solution.

It might be pointed out that within the last few years there have been three large studies on the relocation of railroad grade crossings in the GLA. As of this date, there has not been one single recommendation put into effect. Most of these studies were done by outside consultants who did not have a direct interest in the community. They did not work with the local political structure or with the community in formulating the plans. The consultants did not become involved with implementation. The plans of any transportation activity must be compatible with the local community and in accordance with the thinking of the local people. If this cannot be accomplished, there will simply be a waste of effort and resources in the transit planning process.

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MASS TRANSPORTATION DEMANDS OF SCOTLANDVILLE RESIDENTS

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This study was designed to develop the transportation research expertise of undergraduate students and to provide the local community with information and recommendations that would serve as a basis for improving the level of the local public transit service. The primary data for the report were gathered through home interviews with a view to determining the frequencies and origins and destinations of the various types of trips generated by the Scotlandville residents. A parallel objective of the study was to measure the money, time, and convenience costs involved in making these trips. These data were analyzed along with the street and residential patterns and the socioeconomic characteristics of the population. Massive rerouting of the public mass transportation system was strongly recommended as an outgrowth of the conclusion that many residents of this poor and essentially all-black town could not make the desired or necessary trips to the major work and service centers without the expenditure of an inordinate amount of time and money. The recommendations include a main line connecting with the CBD and a shuttle route serving only the study area and interfacing at various points with the Scotlandville portion of the main-line run. The recommended routing is based on the premise that public transportation should have a maximum of ¼-mile walking accessibility for most residents. The recommendations were fully implemented by the local transit authority, and data from a follow-up study indicate that significant changes have occurred in the time and convenience factors as perceived by the transit riders. The various complaints registered against the system during the first phase of the study were essentially eliminated after the recommendations were implemented.

•THE purpose of this paper is to describe the approach and results of an inquiry made relative to the mass transit needs of a low-density black residential area of Baton Rouge, Louisiana. The first part of the inquiry resulted in recommendations for a greatly expanded transit service, which were almost completely adopted by the local transit authority. The paper also reports certain findings, related to attitudinal changes and revenue generation, obtained in a follow-up evaluation of this new service. The study was undertaken by the Transportation Center of Southern University, which is located in the study area, Scotlandville.

INITIAL STUDY

The decision to study the transit demands of Scotlandville residents was arrived at through a consideration of the following: Southern University received a federal grant for the establishment of a research and training program in urban mass transportation, and the administration of the university had recently established a goal of becoming more actively involved in local community problems; responsibility for the local transit service, previously provided by a private operator, had recently been assumed by

Sponsored by Task Force on Urban Mass Transportation.

a quasi-public body, Capital Transportation Corporation (CTC); and CTC had a capital grants application under consideration by the Urban Mass Transportation Administration, and approval was expected. The capital grants application proposed to purchase the buses and businesses of the black transit operators who were providing bus service from Scotlandville to the central business district (CBD) of Baton Rouge. This action would eliminate these black independent operators and extend the transit service provided by CTC to the Scotlandville area. The objective was to establish one transit system for the greater Baton Rouge area and to provide more reliable transit service.

The regional planning commission and CTC agreed, after considerable deliberation with the university, that the extension of service to Scotlandville should be preceded by a careful study of the transit needs and, if deemed desirable, massive rerouting and rescheduling of the buses; casual observation indicated that both were needed. This research was thus begun with the expressed intent of making proposals for improving the level of transit service provided for the study area; there were sufficient reasons to believe that reasonable recommendations would be implemented.

The Scotlandville Community

Scotlandville is basically a residential area with a population of approximately 20,000. It is a low-density residential area located about 5 miles north of the CBD of Baton Rouge. Geographically, the area is bound by the Mississippi River on the west, an oil storage tank farm on the north, Ryan Airport on the east, Airline Highway on the south, and industrial plants also on the south and east. Casual observation readily reveals that the community developed in a piecemeal and haphazard manner as evidenced by dead-end streets, residential areas interspersed with commercial activities, vacant lots, open ditches, several unpaved streets, and few sidewalks. In the midst of this community are located two middle-to-high-income residential subdivisions, inhabited mainly by Blacks who are professionals. Except for these relatively new subdivisions, large tracts of underdeveloped land are scattered throughout the predominately residential areas. Great distances between connecting streets and strip development perpendicular to the streets on deep lots have resulted in haphazard street patterns, poor internal circulation and access, and small frontage.

This inefficient and disorderly pattern coupled with the low density of the population contributes to the transit problem of the area; the transit routes are restricted by the present dead-end and narrow street system, poor internal circulation, and wide dispersion of the population.

Former Transit Service

When the first phase of this study was begun, the primary bus line serving the area was operated by a loose association of individual operators, and there was no company or transit authority regulating the service provided to the community. Local governmental control existed only in the form of temporary permits granted by the city to individual owner-operators. Most of the operators were poor Blacks who owned vehicles that were noticeably unreliable and unsafe. Without describing the buses or their schedules or routes, suffice it to say that the service was unreliable, inconvenient, uncomfortable, and unsafe. The university agreed at the outset that, in the interest of better service to the total community, publicly owned and operated buses for the area should not be discouraged. Our survey later revealed that the community was generally in agreement with this attitude. Both the community and the university insisted and received assurances that the independent bus drivers would not lose their jobs. These privately owned buses operated only with the revenue from the fare box and had been forced to constantly cut service to many areas in order to break even. The total system ceased operating after 7:00 p.m. each day. The users of this system not only were without transit service after 7:00 p.m. but did not, without time-consuming transfers to the city system in the CBD, have access by these buses to most of the hospitals, shopping centers, and other work and activity centers during normal working and shopping hours. When transferring between the two systems in the CBD, the passenger paid the full fare twice.

Research Methodology

Mass transit service was almost nonexistent in the area. The problem, therefore, was to answer the following questions: What are the origins and destinations of desired transit trips? What are the trip types and frequencies? What is the modal split of the total trip-making for the community? What is the cost distribution of transportation for the various subgroups in the area population? More specifically, what are the desired transit trips that are not possible on the existing system, and in what ways may the community be better served?

All of the planning documents that described various components of the community infrastructure were studied for background information. We surveyed the physical characteristics of the area—street layout, location of residential areas and distances between them, and distances between residential areas and attractors of transit trips. A travel-time study was conducted to ascertain the travel time to various points from the center of Scotlandville, and these data were used in simulating mass transit schedules. The area was then delineated by a series of traffic zones taken from the State Highway Traffic Zone Map. In collecting and analyzing these data, some of the traffic zones were broken down into parts to delineate areas of high socioeconomic status in an effort to further stratify trip-generating characteristics. Sample households were randomly selected. The instrument for the home-interview survey, the primary source of data for this study, was designed by student and staff participants.

Community Profile

Scotlandville is not a community that is in sociological transition. A breakdown of the tenure status of the household (based on a sample of 210 households) indicates that 69 percent owned or were buying their places of abode; the other 31 percent were renters. About one-third of the occupied houses would generally be considered substandard (4, p. 51). The Interstate bypass, which will cut through the community within the next 2 years, is the only foreseeable development that will appreciably alter the proportion of substandard houses and the composition of the total population. Though the bypass will have a minimum displacement effect, approximately 250 houses, mostly in the substandard category, will be destroyed. In further substantiating our contention that there are few factors contributing to migration, it should be emphasized that only 12 percent of the household heads expressed some degree of willingness to move outside of the area.

The average household size is 4.14 members. Although most households had 2 members, a significant proportion (70 percent) of the population was in households of 3 or more members. Children of school age and younger constitute a fairly large proportion of the total population. The median annual income of the households is $4,674. This average is significantly influenced by the fact that about 20 percent of the applicable household heads in the labor force are professional workers, mostly university and public school teachers. Rough calculation of the coefficient of correlation reveals no significant relation between household size and family income.

Twenty-three percent of the applicable household heads are service workers, including private household workers. The breakdown of the employment statuses of household heads shows that about 60 percent are full-time workers, and about 25 percent are either retired, disabled, or unemployed and have an income that is less than the median.

The data show that age significantly influences employment status. The unemployed, retired, and disabled are mostly the aged with the unemployed appearing among the young and the elderly. Because some relation exists between age and employment status, it follows that the same pattern between age and income should also emerge, and the data substantiate the inference that the aged and very young are heavily concentrated in the lower income groupings. The median age of household heads is 43, and the median population age is 24.

A definite relation exists between education and occupation; the professional workers have a median education of 16.41 years, and no other occupational group's average education is more than 12 years. Education, therefore, does exert some influence on income, and the relation that emerges is positive. The median income of those having completed 9 or more years of education is more than $5,000.

Travel Patterns

The average number of trips per household head per week is 11, whereas the average is 33 for all members of the household. This is quite low in comparison with the overall Baton Rouge area, for which the average daily number of trips per household is 8.8 (5). The frequency of trips per household appears to be positively influenced by household size and income. Education was also found to be positively related to trip-making. The age of a person appears to have a slight positive correlation with trip-making until age 55; at the ages above 55, it decreases significantly.

The aggregate travel demand for the area varies in some ways from the norm. As usual, the most frequent trip purpose is home-return (48 percent). Although the proportion of work trips (21 percent) would appear to be about average, that for school trips (12 percent) is very high. This may be explained by either one or both of 2 factors: Many Southern University students live in the study area and commute to school; and, although total trip generation in the area is relatively low, school attendance rates for children are normal—hence school trips constitute a large proportion of total trips.

The hourly distribution of trips is quite sharply peaked—roughly 18 percent of total trips occur in both the morning and afternoon peak hours in spite of the fact that shift-work and irregular work hours result in a wider distribution of work trips throughout the day. This can be attributed to the importance of school trips coupled with the relatively low volume of discretionary trips, which tend to be made during off-peak periods. Furthermore, the afternoon peak hour centers on 3:00 p.m., the time when the public schools recess.

Roughly 66 percent of all these trips were made by private automobile or truck, and about 9 percent were made by public transit. The other 25 percent were accounted for by other modes, primarily school buses. It is interesting to note that the destinations of trips originating in Scotlandville are almost evenly divided between Scotlandville and other parts of the Baton Rouge area, 51 percent and 49 percent respectively, but that about 79 percent of the bus trips were destined outside Scotlandville.

Automobile ownership in Scotlandville is comparatively low; 35 percent of the households own no automobile, and only 20 percent own 2 or more automobiles. In addition, 35 percent of the household heads indicated that they use the Scotlandville bus system, and, of the total number of persons making some use of the system, 57 percent used it either frequently or fairly often.

We infer that about one-third of the population desires and needs—on the basis of income, location of work site, and availability of private transportation—to make frequent use of the transit system for work and shopping trips. It has been pointed out that about 23 percent of the household heads are service workers. These service jobs are invariably located outside the Scotlandville area, and the average income from these jobs is such that the high costs of taxi and other transportation modes tend to discourage work and/or employment-seeking. Significantly, most of these workers reported that their transportation costs are too high. There is some reliance on taxi service and special bus runs to hospitals, motels, hotels, and restaurants, which is financially burdensome for the low-income service worker.

Need for a New Transit System

The need for an improved level of transit service was verbally expressed throughout the survey. The car pool is an alternative not used by Scotlandville residents. The data suggest that the work places of the poor are too dispersed, and too few of the poor own automobiles for this alternative to be used. For the other income classes, low traffic congestion and transportation costs do not induce appreciable multiple-car occupancy for the work trip.

Data generated relative to reasons for not riding the bus revealed that the lack of accessibility to the buses and the fact that they were not routed through many places of work, shopping, and other service centers decreased ridership. The conclusion was reached that the frequency of use and the proportion of the population using the transit system would increase when the new system and routes are introduced. The low level of service of the then existing system necessitated the development of alternative means

of transportation, many of which were not permanent arrangements. Rerouting and rescheduling were expected to increase the number of all types of transit trips. It was discernible from the data that trip frequencies and patterns were somewhat restricted by the present routes and level of service. It was anticipated that the new transit service would reduce the transportation hardships of the aged, the working and nonworking poor, and the occasional transit rider. Sixty-five percent of the households owned automobiles, which indicates that Scotlandville has low automobile ownership. Transit in the area is important—not a marginal need or service. However, we did not anticipate that more reliable transit service would induce more transit trips among persons who have access to private automobiles. The people who did not ride the bus gave the ownership of an automobile as the main reason for not riding. The inaccessibility of the present system was the next major reason followed by general dislike of transit, inability to travel, and lack of flexibility of the system. Of those who rode the local transit system, 80 percent were dissatisfied with the service, and the chief complaint was unreliability. Only 16 percent expressed satisfaction with the present service.

Ninety-five persons who used transit ranked the system for complaints on a rating scale of 1 to 5. Although reliability was most frequently registered as a first complaint, comfort emerged as the most frequent complaint when second and third complaints were taken into account. The other complaints that were cited often included untidy and unsafe conditions and lack of service at certain hours.

None of the residents thought that the bus fare was too high. The median cost of transportation per week was $7.29 (approximately 8 percent of median income), and the median work trip length was 16 minutes with an average mileage of 6.5. In anticipating a new transit system for Baton Rouge, the residents were asked if they would support a shuttle service to feed the main-line systems into Baton Rouge. Eighty-five percent of the people indicated they would do so, and 90 percent of them indicated that they would pay up to 25 cents for one fare.

The foregoing information served as a basis for our conclusion that an extension of the public transit service to the study area was warranted. The next step was to determine the areas that should be specifically covered and the routing of the buses. The population density and household income of the areas along with the trip data generated by zones enabled us to map the routes and recommend headways.

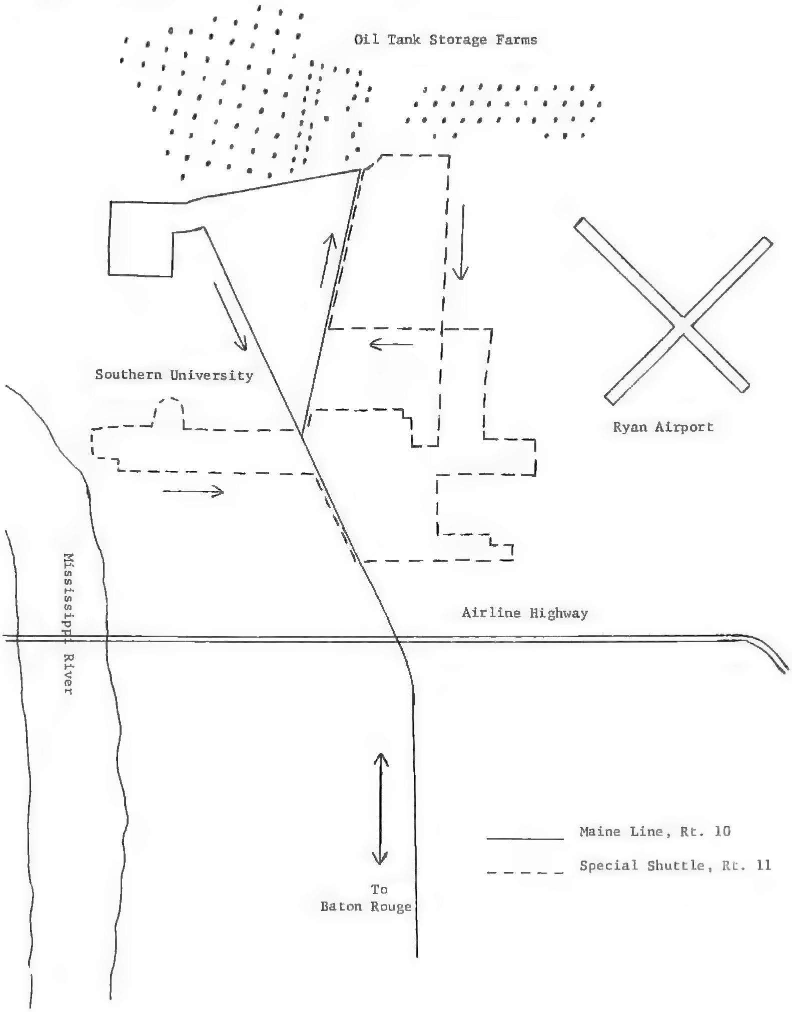
Alternative Actions

On the basis of these data, routes for a main line and a shuttle service to feed it were developed (Fig. 1). Strategic points were pinpointed for transfer from the shuttle to the main line. A graphics technique was used to determine the location of the routes. The rationale for the graphics was the concept that an individual should be no further than ¼ mile from a bus route and not more than 3 blocks from a bus stop. Routes were developed and then tested by actually driving them and checking the feasibility of route locations and bus stops.

The corridor concept fixed the route location, whereas the stops were pinpointed by the accessibility concept. The most favorable stops were selected from the overlapping 3-block cells of accessibility. Favorable routes were chosen based on the trip production information by zones and accessibility by the largest concentration of likely transit users. Natural constraints and street conditions and patterns also influenced the final routing plan. Analysis of our data enabled us to make route predictions of the transit needs by zones and to establish routes that would make the service reasonably accessible to the largest possible number of residents.

The widely dispersed population of the area forced us to recommend a main line, connecting with the CBD, and a shuttle route serving only the study area and interfacing with the main line at various points. If the main line, which connects directly with the CBD, covered the total area, the headways would be much higher, and this would be intolerable on the line-haul portion of the Scotlandville run. The main-line routes do traverse the portion of the area that generates the greatest number of transit trips. Fifteen-minute headways were recommended for the main line, but slightly higher headways were considered quite acceptable for the shuttle, which covers a much larger

Figure 1. New transit routes in Scotlandville.



portion of the area. The university campus is included in the recommended shuttle routes—the first time it is being served by the public transit buses on a scheduled and regular basis. In addition, we suggested that Scotlandville residents be connected by transit directly with an area that can be described as a corridor in which are located the major shopping centers serving the area and the service-oriented jobs of many of the poor. Currently, area residents must travel to the CBD and transfer to a line that serves Airline Highway—but Airline Highway is closer to Scotlandville than it is to the CBD.

Implementation

The new transit system, with its extension of service to Scotlandville, will significantly improve the level of service to the area. The shuttle service, operating through widely dispersed residential sections of the area where there was no prior transit service, was expected to barely meet the cost of its operation. However, the shuttle and the main line together would not be a financial drain on the system. The shuttle must be given time to build its ridership because, where there was no prior service, other means of transportation have been developed by most of the residents. However, the

revenue from the main line was expected to be substantial from the outset. Fortunately, the entire Baton Rouge system is partially subsidized with revenue from parking meters, a factor that will allow management to maximize service to the community.

One week after these recommendations were made, the manager of the transit company made a physical check of the recommended routes along with the director of the Transportation Center. He adopted the recommended routes, except for a few minor adjustments due to street conditions, and announced that the new service would be extended to Scotlandville beginning the following week. The direct service to Airline Highway was deferred pending further study and the acquisition of additional buses. Special transit service for workers along this highway is being provided once in the morning and once in the afternoon by one of the old independent operators.

FOLLOW-UP STUDY

The continuing research project at the Transportation Center involves a follow-up study of the recently implemented transit service in two respects: It compares the new transit service in the Scotlandville area with the previous service and attempts to assess the ridership response to this presumed improvement; and it extends the former study by reevaluating the criteria on which the routing of the special shuttle is based. This study also analyzes the need and justification for a second main line connecting Scotlandville directly with other parts of the greater Baton Rouge area, especially to points (other than the CBD) outside the study area that attract a significant number of trips originating in Scotlandville. The follow-up study also employed a home-interview survey, which included all those households interviewed last year that are occupied this year by the same residents.

Although the bulk of the data obtained in the household survey is detailed trip information, the information that to date has been tabulated from the field forms relates to the residents' opinions and attitudes toward the changes in the transit service and the level of service of the present system. Although this information is intended to fit into the larger framework of the study, it might prove to be interesting if looked at separately.

Public Awareness

The total sample in the survey was 248 households, and of these 86 percent indicated an awareness that some changes had been implemented in the transit system serving Scotlandville. It should be noted that this awareness results primarily from the visibility of the service itself, spread further by word of mouth; no special promotional campaign was mounted to publicize the changeover in an effort to increase ridership.

Of the total sample, however, not all had noticed the same specific changes. Predictably, the presence of new buses was the change most strongly felt. About 81 percent of the total sample noticed this change. In terms of actual service, the most important change is the operation of the buses on totally new routes and schedules, and as expected this change was also observed by a high percentage of the respondents although not by as many as noticed the new buses. About 71 percent of the sample responded that they were aware of the new routes and schedules.

Another difference between the old and new services, about which the residents were questioned, was the change in fares. It should be noted that, in terms of fares, the public takeover of transit service in the greater Baton Rouge area did not affect Scotlandville residents in the same way that it affected transit riders within the city limits of Baton Rouge. With the assumption of responsibility for transit service by the CTC, a standard one-way fare of 30 cents was set for all routes in the system. Although this meant that there would be no change in fare for previous customers of the city system, the fare for the riders of the independent line serving Scotlandville was 25 cents; thus, Scotlandville transit riders were faced with a slight fare increase of 5 cents, albeit for better service. A total of 70 percent of the respondents indicated that they were aware of this fare increase.

General Opinions

Fifty-five percent of the 248 persons interviewed said that they had used both the old and the new bus services and thus were in a position to make comparisons. Almost all of them, 98 percent, responded that the service is better now. We can safely infer that virtually the entire community is in agreement on this point. Fully 93 percent of those interviewed said that their total door-to-door travel time for trips made regularly by transit is less now than with the old service. Also, 66 percent of the respondents said that the walking distance from their home to the bus stop is less now than before. Reductions in total travel time and walking distances can be explained by the fact that the new system has many more route-miles within the Scotlandville area and that waiting time is decreased due to the increased frequency of buses running on these routes.

Exactly 50 percent of the persons interviewed said that some member of the household rides the bus regularly at present. About 89 percent of these respondents were of the opinion that the distance walked from their home to the nearest bus stop was a reasonable distance. They were then asked how many blocks this distance was. About 75 percent of these households (123 subjects responded) are located within 2 blocks of a bus stop and almost 95 percent within 4 blocks. Three to four blocks (¼ mile) is generally considered to be the maximum distance that regular transit riders should be expected to walk to the bus. The Scotlandville run, therefore, would appear to measure up very well in this respect. This is not at all surprising because the special shuttle was designed primarily to extend transit service from the main line over broader sections of Scotlandville, a relatively dispersed area; and its routing was based on the corridor-cell concept in order to obtain complete coverage in the community.

Some 47 percent of this same group of present-day transit riders indicate that they now make some trips regularly by transit that they formerly made by other modes. This should represent a substantial increase in overall ridership, and it will be interesting to see whether the trip information, now being tabulated, confirms this. These people were also questioned as to whether there are destinations outside the study area to which they travel that at present cannot be reached either at all or directly by transit. In total, 14 percent answered in the affirmative.

Significantly, many of the destinations cited correspond with the Airline Highway route alignment previously mentioned. The feasibility of such a route, which would connect Scotlandville directly with many of Baton Rouge's most prominent outlying shopping centers, service-oriented job centers, and affluent residential areas employing domestic workers, will shortly be under study by the technical committee of the transit company. One objective of this research project, therefore, is to determine the potential Scotlandville-based ridership for such a line.

In terms of numerical significance with regard to the total population, the survey sample cannot be considered to be accurate with respect to specific locations and travel destinations; however, it can be validly interpreted in terms of general areas or groupings of destinations. The results of this inquiry would appear to indicate that there is still a need for transit service connecting residents to areas along or adjacent to the Airline Highway and the eastern segment of Florida Boulevard. The area to the north of Scotlandville, including the outlying communities of Zachary and Baker, was mentioned by a few respondents and is a possible problem area for further study. Detailed analysis of current travel patterns with respect to trip purposes, frequencies, and modes, to be performed later on in this study, should fill out the dimensions of this travel demand and provide a better basis for any possible recommendations for increases or changes in service.

Comparative Ratings

Some of the questions on opinions and attitudes included in the first-year home-interview survey were repeated verbatim this year to facilitate a comparison of attitudes toward both the old and the new services. These questions are somewhat more objective than the one previously discussed in that they do not ask the respondent to make a comparison himself. Rather, they ask the sample groups in each year to evaluate the existing service in a number of ways, and then these assessments, made before and after the implementation of new service, were compared and analyzed.

In one question, present-day bus riders in each year (1970 and 1971) were asked to rate the overall service on a scale including the following possible responses: extremely satisfied, satisfied, no opinion, dissatisfied, and extremely dissatisfied. In 1970 only 15 percent of those interviewed responded that they were extremely satisfied or satisfied with the old bus service; in 1971, 96 percent said that they were either satisfied or extremely satisfied. Conversely, the percentage of respondents answering that they were dissatisfied was reduced from 62 percent in 1970 to only 2 percent in 1971. Whereas 19 percent felt extremely dissatisfied with the old bus service in 1970, no one answered extremely dissatisfied in 1971.

We at the Transportation Center feel that to some degree this may be an overstatement of the current level of satisfaction with the existing transit service; i.e., some respondents may have felt that we were looking for a positive reaction and thus shaded their answers accordingly. This kind of procedural problem is difficult to avoid in a situation where the service being evaluated is implemented based primarily on recommendations of the investigators themselves, but, in the main, this tremendous upward shift should be considered a valid reflection of the community's attitudes.

Parenthetically, it is also our subjective judgment at this point that the high level of satisfaction with the current service is itself an overstatement of the level of service being provided. Complete rerouting and substantial upgrading of schedules, along with the provision of new and air-conditioned buses, night and weekend service, and, in general, a more business-like operation, are obviously a great improvement over the old, loosely run service, but that is not to say that the new service is completely meeting the area's transit needs. Part of the reason why 96 percent of the respondents indicated that they were satisfied with it may be the extremely low base on which the comparison is made; the old service was almost nonexistent, and, conditioned by this fact, the residents might be expected to be overenthusiastic toward any attempt to provide a new and improved service. In general, though, such a favorable response should be interpreted as reflecting the great magnitude of change in service levels provided by the old and new systems.

Present-day transit riders in both years (1970 and 1971) were also asked about their complaints regarding the transit service. Several possible complaints were suggested, and other kinds of complaints not specifically suggested could be registered as "other." Significantly, no single complaint was voiced by more than 6 percent of the respondents regarding the new transit service, whereas in 1970 there were many large percentages.

The biggest single complaint (50.8 percent of the respondents) in 1970 was that the buses were uncomfortable. In 1971 this was reduced to only 4 percent. Probably the most important factor regarding this difference is that the new buses are air-conditioned and give a much smoother ride. The complaint of unreliability went from 39.3 percent in 1970 to only 3.2 percent in 1971, undoubtedly a reflection of CTC's insistence that the drivers maintain the schedule. Also, schedule control under the old service was very loose, and when machines broke, which was frequently, they could not be replaced in the schedule. Two complaints, untidy and hazardous and unsafe, were mentioned by 33.6 percent of those interviewed in 1970; in 1971 these figures were 2.4 and 0 percent respectively. Both the new machines and the management's concern about maintenance are certainly responsible for the vastly reduced intensities of these complaints.

Complaints about bad drivers, which were never very numerous in comparison with other kinds of complaints, decreased from 9.8 to 3.2 percent. Although many of the current drivers are former drivers of the old blue buses, the reduction of the frequency of the complaint can be attributed to the much closer supervision provided by CTC management. Two complaints, bad headways and bad times, might seem somewhat ambiguous, but they are intended to measure two different aspects of the service. Headways refer to schedule frequency, and this complaint, surprisingly low last year in view of the fact that headways were fairly high, was reduced from 6.6 percent in 1970 to 3.2 percent in 1971. Bad times refers to times of the day or week; more specifically this complaint relates to the lack of service at night or on Sundays, and it went from a high of 27 percent (in 1970 the buses stopped running at about 7:00 p.m.) to a low of 5.6 percent in 1971. This complaint was registered in 1971 more than any other single complaint, probably a reflection of the shuttle not running on Sundays and reduced service at night.

Interestingly, the only complaint that was registered more times in 1971 then in 1970 was that the service is expensive. This can be attributed to the increase of main-line fare from 25 to 30 cents. Expense is now the second highest complaint after bad times. The category for "other complaints" was not included in the 1970 questionnaire, hence its score of 0 percent. In 1971 it was included to give people a chance to relate complaints that were not specified in the questionnaire. This catch-all category had a high percent, 6.4 percent. The most common complaint in this category was that certain destinations were not easily accessible by transit.

In summary, this comparison shows very significant changes regarding both the level and the kinds of complaints made by Scotlandville transit riders. Regarding the old independent bus service, complaints were very frequent, especially with reference to discomfort, reliability, untidiness, safety, and times of operation. In 1971, the level of complaints was generally much lower—no complaint is more than 6 percent—with the exception of expenses, which actually rose. Also, other complaints, primarily regarding routing, were registered with a relatively high frequency.

In both years, participants in the survey who were not transit riders were asked their reasons for not riding the bus. In both years, the main reason given was that respondents owned their own automobiles or trucks and preferred to use these for their daily transportation. This is certainly not surprising, as automobile ownership is usually seen as the prime determinant of modal split, and, as has been pointed out previously, it is low automobile ownership that makes Scotlandville important in terms of mass transit ridership.

Some additional reasons that were registered were "don't like the bus," "inflexibility," and "other." These are minor complaints, however, and another possibility, discomfort, was not cited at all. It is significant that in 1971 the reasons for not riding the bus were more concentrated in the categories "own transportation" and "don't travel," reasons that do not directly reflect on the transit service itself. In 1970 the second most important reason cited was the lack of accessibility of transit, at 10 percent; in 1971 no one gave this as his reason for not using the bus service.

Revenue Analysis

The ratio of revenue to miles traveled for the Scotlandville line compares favorably with other lines in the Baton Rouge system and gives some measure of the response to the service and the need for the same. The Scotlandville line, serving a sparsely populated residential area, is the fourth most revenue-generating line in the system of 12 lines. The fact can be explained simply because of the relatively low median income level in the area. One must be cognizant of another fact in interpreting these revenue per mile data: The 5-mile distance between the city limits and the CBD consists of "dead miles" for the Scotlandville line because there is little pick-up of passengers over this range on the inbound trip and little discharge of passengers on the outbound trip. The average revenue per mile is around 67 cents and 64 cents respectively for the Scotlandville line and the system as a whole.

Research in Progress

In addition to the home-interview survey, an on-board passenger survey and a boarding and alighting count are planned as part of the follow-up study. Travel information obtained from these three sources will be compared with data from 1970 to analyze the change in level of service in terms of total travel time, waiting times, and walking distance. Ridership response to the change in service will be calculated in terms of passenger volumes, and the patterns of transit trips, frequencies of trips for various purposes, and geographic distribution of trips will be examined.

The level of service provided by the present system, measured by total travel time, will be evaluated on the basis of its comparison with that provided by private automobiles. The feasibility of a second main-line route and express bus service, two potential ways of reducing travel time, will also be studied. Finally, the shuttle line will be analyzed in detail to determine whether a more favorable route can be found that would reduce headways, provide more direct transportation between origins and destinations, and increase ridership.

CONCLUSION

The results available to date are extremely favorable regarding the newly operating integrated transit service. Awareness in the community of the change in service, specifically relating to the highly visible new buses, the changed routes and scheduling, and the fare increase, is much more widespread than actual use of the system; many people who do not ride the new system have, in a short time span, become aware of its existence. Virtually the entire community appears to be in agreement that the new service is an improvement over the previous service, and overwhelming majorities said that their walking distance to bus stops was shorter, that the time spent waiting for the bus was less, and that their total travel times were shorter.

A comparison of bus ratings by transit riders in 1970 and 1971 reveals a tremendous shift upward in the general level of satisfaction with the new service, with 96 percent of the residents saying that they were satisfied or extremely satisfied with it. On the other hand, the number of most complaints regarding service decreased sharply with the new service. The only complaint that was registered more frequently in 1971 than in 1970 concerned expense, and this can be attributed to the slight fare increase sustained by Scotlandville transit riders. Among nontransit users, the most frequent reason for not riding the bus in 1971 is the preference for private transportation. Complaints about the lack of accessibility of the service were completely eliminated in 1971.

Although we will be analyzing hard data measurements of the operating characteristics of the new transit service, it is equally important to understand what the community's attitude is toward this service. How the residents perceive their travel needs and the effectiveness of the service in meeting these needs may be quite different from the way we judge them according to our "objective" criteria. It could be the case, for example, that the new service is providing only marginal improvement in terms of decreasing actual travel time, and yet the high visibility of the new buses and changes in operations have promoted an extremely positive initial response that is totally disproportionate to this slight improvement in terms of travel times.

Is the overwhelmingly favorable response garnered in the home-interview survey a reflection of real improvements in the service provided according to our objective measures, and does it mean that more discretionary trips are made by transit and that more trips are made by transit when other modes of transportation are available? These are questions that we intend to examine further in the course of this research project. Possibly, we will find that there is little correlation between an evaluation based on the standard objective criteria and the way the riders and nonriders perceive the service, an indication that there are other, less tangible factors at work in the formation of people's attitudes toward transit and their daily decisions about their own travel habits.

The point is that, besides objective evaluation of service capabilities, we need to understand how people in the community feel about the service. With this in mind, we at the Transportation Center have begun to investigate the community's attitudes. Admittedly, this is a very modest first effort; but this is an area in which we intend to devote more time and resources in future research and one that will play a more important role as attention gradually shifts from providing transit almost solely as a service for captive riders to promoting its attraction in a wider market.

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EXAMINATION OF IMPROVED TRANSIT SERVICE

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•THE municipality of Iowa City instituted a conventional transit system in September 1971 that replaced a private system that had ceased operation. New 45-passenger buses, an increased level of service, and a reduced fare (25 to 15 cents) were provided. The level of service was increased from seven to ten routes, which provides a 20 percent increase in coverage and a 39 percent increase in mileage. A considerable increase in patronage is being experienced as a result of the reduced fare and the increase in level of service. A 165 percent increase in patronage has occurred for the period September 1971 to February 1972 as compared to the same period in 1970 to 1971 (678,976 fare passengers in the 6 months of 1971 to 1972 as compared to 256,294 in 1970 to 1971).

Iowa City is approaching a population of 50,000, and the urbanized area contains nearly 60,000. This includes 20,000 University of Iowa students. As in many communities of this size, there exists a great dependence on the automobile, and transit handled a decreasing proportion of the trips in the urban area during the 1960s—from 4 percent of all trips in 1964 to 1 percent in 1970. However, the adjacency of the University of Iowa campus to the central business district (CBD) provides a single, strong central focus that can be served effectively by transit.

The authors of this paper conducted the mass transit technical study (1) for the Johnson County Regional Planning Commission. While the study was in progress, it became evident that the municipality of Iowa City was best able and most willing to operate the public system, which made it the effective client for the study. The mass transit technical study recommended routes, estimated costs, and estimated patronage for the new municipal system. A three-stage implementation, to be carried out during a 3-year period, was recommended. The first stage called for establishing the new operation with essentially the same number of routes that had existed before. The second stage called for increasing the number of routes by three, and stage three was designed to bring a suburban carrier into the system. The recommendations of the mass transit technical study were followed closely, and the system was established before the final report was published. The city council chose to implement the system through stage two, immediately.

The purpose of this paper is to describe the nature of the prior service, the recommendations of the mass transit technical study, the patronage response to the improved service, the impact of the improved service on traffic and parking, capacity problems of handling patronage, the technical and policy questions of additional improvements to the level of service, and continued studies of transit that are under way. The discussion of these items in the Iowa City context provides a perspective on instituting a successful transit service. However, success, in terms of nearly tripling patronage, still requires subsidy and has brought capacity problems and even higher expectations for transit.

PREVIOUS SERVICE

Transit service in Iowa City had reached a crisis stage during 1970 as the private operator, in the face of the classical problem of declining patronage and rising costs, notified the city that he planned to cease operating transit service. In addition to oper-

Sponsored by Task Force on Urban Mass Transportation.

ating a seven-route city transit system, the Iowa City Coach Company operated a charter bus service and a school bus service for Iowa City Community School System. The city transit service had become a serious drain on an otherwise profitable operation.

Service Level

The Iowa City Coach Company operated a continuous-service line-haul system, using 31- and 35-passenger coaches. The average age of the buses was nearly 14 years. Five of the seven routes contained long loops that were used to expand the area coverage of the limited system. Service hours were from 6:30 a.m. to 6:30 p.m., 6 days per week. Headways were 30 minutes on four routes and 20 minutes on the remaining three. There had been little attempt to expand service to new growth areas of the city, even though the city's population had increased by more than 40 percent in the 10-year period from 1960 to 1970. The level of service during the 1960s was fairly constant.

Early Subsidy

The increase to a 25-cent fare in the spring of 1966 drove ridership to a record low and actually produced a decrease in revenue. In an effort to maintain some form of transit service, the university agreed to subsidize the transit system at $3,000 per month, with the stipulation that university students be allowed to ride for a 10-cent fare. The result was an immediate doubling of ridership.

Because of pressure from local citizens, the city council agreed to share in the subsidy, increasing it to $5,000 per month, and the general fare was reduced to 10 cents. The subsidy created a highly profitable arrangement for the private operation though it was difficult to determine the extent of the profit because the company also operated a school bus service and charter service. The year-end audit seemed to indicate an oversubsidization, with excess profits being earned by the operator. This resulted in a demand for extended service, which the private operator refused to do, and the subsidy was withdrawn.

A labor contract, negotiated in 1967, raised driver wage levels nearly 40 percent. This contract, coupled with the cessation of the subsidy agreement, created a rising cost-constant revenue situation. In an attempt to cover costs, the private operator began raising fares in 5-cent increments to the 1970 level of 25 cents. The fare increases raised revenues but drove away choice riders. The result was further financial losses as cost continued to rise faster than revenue.

Final Subsidy

In the spring of 1970, the owner, who had been operating without a franchise, threatened to terminate service as of June 6, 1970. The regional planning commission was in the process of contracting for a mass transit technical study at this time. A publicly financed system was being considered, but it was at least 1 year away from implementation. As a stopgap measure, the city entered into an agreement with the private operator to continue service. The city agreed to pay the Iowa City Coach Company $90 per day per route with the city retaining all revenues. As a result, the city has paid up to $9,000 per month in subsidy. This agreement continued for 14 months at a total cost of $81,805 ($220,000 cost as compared to $138,000 in revenues) until September 1, 1971, when the improved public service was implemented.

MASS TRANSIT TECHNICAL STUDY

In mid-1970, the Johnson County Regional Planning Commission received a mass transit technical study grant from the Urban Mass Transit Administration (UMTA). The Center for Urban Transportation Studies of the Institute of Urban and Regional Research at the University of Iowa was awarded a contract to develop a short-range transit plan, consisting of an analysis to recommend alternative route patterns and to estimate their patronage and cost.

During the course of the technical study, the Johnson County Regional Planning Commission explored alternative agency arrangements for operating the system. It became apparent that the municipality of Iowa City was willing and best able to provide transit service. The city administration then restricted consideration of alternatives to a level of service that would maintain subsidy requirements to less than $100,000 annually and would require capital investment on the order of 10 to 15 buses.

Findings

The technical study made findings in five general areas: routing, headways, hours of operation, fares, and service variables.

The existing routing patterns had three severe shortcomings. There was no service available to new growth areas of the city, residential or commercial. Loop-type route patterns were used to gain wider coverage, doubling ride times and lowering the level of service to residential areas. No use was made of crosstown routing patterns to better service the west campus-hospital area.

The 6:30 a.m. to 6:30 p.m. hours of operation were reasonable, considering that evening service would not generate enough revenue to cover variable costs. However, analysis indicates evening service could be justified on several university-related routes.

An on-board survey showed that the 25-cent fare was attracting primarily captive riders and few choice riders. Past experience had indicated that a fare greater than 15 cents was unattractive to the choice rider. In general, the results of the on-board survey are similar to results of studies conducted in other cities, indicating that transit patrons were largely captive riders.

The quality of service was low. The buses were old and uncomfortable, and they lacked air-conditioning and flow-through heat. The streets on which transit operated were narrow, yet on-street parking was allowed. Little consideration was given to facilitating transit traffic. Bus drivers received little training or incentive to build a better public image.

Recommendations

The recommended system was designed to provide an adequate level of transit service at a cost the city was able and willing to pay.

Crosstown routes were utilized to provide service to the west campus from all areas of the city. The routes were located so as to eliminate duplication and to be within three blocks of most residential locations. Ten routes, as compared to the previous seven, were recommended. Extension of shorter routes increased some headways from 20 minutes to 30 minutes, but line routing decreased average ride times. Twenty-minute headways with nighttime service were proposed from the two routes serving primarily university students.

Assessment of several alternative fares was made to provide information to the city for a policy decision regarding fare structure. However, a fare of 15 cents was recommended. It was predicted that the lower fare would bring bus service to more people in the community, which is an objective of the publicly owned and subsidized system. In addition, a student fee was suggested. The student fee would consist of perhaps a 5-dollar fee per semester for all students. This fee would give students transit service throughout the entire community during that period, requiring only presentation of a university ID card, and would provide a basic funding floor for the transit operation. However, the city instituted a flat 15-cent fare.

The Iowa City administration, in concurrence with the Johnson County Regional Planning Commission staff, chose to purchase all 45-passenger buses rather than a mixture of 45- and 33-passenger vehicles. This choice was based on the advantages of maintaining only one type of vehicle and having extra capacity when needed. Also, when total labor, maintenance, operating, and depreciation costs are considered, the difference in purchase price between a 45-passenger bus and a 33-passenger bus is not significant. Furthermore, the larger bus was felt to be more durable, and it contained an air-pollution control package that was not available on the 33-passenger bus.

Comparison of swept-area diagrams for turning movements for the 33- and 45-passenger buses shows little difference. These advantages were felt to offset the advantages of a smaller, more maneuverable bus.

It was also recommended that the city provide for the elimination of on-street parking for transit routes on narrow streets, lengthen curb radii at certain intersections to improve turning movements, and improve traffic flow on heavily traveled streets used by transit vehicles.

Patronage Estimates

Initially, a trip split model was formulated by using data from the Iowa City Origin and Destination Study completed in 1964 by the Iowa State Highway Commission. The dependent variable, percentage of total person trips using transit, was related to variables of three types: production-end variables, attraction-end variables, and zone-to-zone service variables. The resulting estimating equation was unsuitable because it was based on a small relative number of transit trips, 197 transit trips out of 11,512 person trips. It was a better descriptive than predictive model, and the model was not sensitive to changes in level of transit service.

Consequently, a purpose-specific model was developed utilizing the on-bus survey data gathered during the mass transit technical study and projected interzonal transfers. Because 91 percent of all transit trips either started or ended in the CBD, and because this zone was to continue to be the central node in the new system, it was decided to concentrate on predicting purpose-specific attractions to this zone. The new total trips produced were based on increasing the 1964 interzonal trip matrix by 3 percent per year, which is the method used by Iowa City in estimating traffic. The control total of transit trips was obtained from the sum of percentages of transit use in zones currently served by transit.

Use of this method enabled us to better utilize Iowa State Highway Commission projections for the transportation study, and it also gave us a greater sensitivity to level of transit service in predicting future ridership. Three trip purposes were used: work trips, school trips, and other trips.

Manual assignment was made to account for service to proposed university peripheral parking lots, replacements of existing private transit service, and an improved, extended hour service to university housing areas. The resulting trips were then allocated to bus routes and checked against current data for accuracy.

Implicit in the modal-split estimation is a 25-cent fare that was in effect at the time of the on-bus survey. Past patronage data were analyzed to detect relations between fare and patronage. Patronage data, when prior subsidies and reduced fares were in effect, provided good information for determining the impact of fare on patronage. A very high degree of correlation was found, particularly when university enrollment was introduced as a controlling factor. These relations are given in Table 1. The results of this analysis were then applied directly to the results of the modal-split equation to indicate changes in patronage. In retrospect, separate equations for summer and school year should have been used. This would have removed the need for using enrollment as a variable.

Implementation

The recommended system was implemented by the city on September 1, 1971, with several exceptions: no nighttime service was provided; all routes had 30-minute headways; no university subsidey was provided; no budget provisions were made for bus shelters and other amenities; and the suburb of Coralville continued its separate service.

ANALYSIS OF PATRONAGE RESPONSE

There has been a substantial increase in patronage as a result of the new transit service in Iowa City. New routes, new 45-passenger buses, and reduced fare (25 to 15 cents) are the principal reasons for the increased patronage.

The Iowa City transit system is maintaining daily and monthly statistics generated from fare-box revenue and is supplementing the data with counts of the number of

passengers by time of day on each route. So far, the data are comparable with data collected for the prior service; they show a wide variation in monthly ridership that responds to university enrollment and climate. Figure 1 shows the percentage of annual patronage by month for the prior service. These percentages were calculated from 12-month periods when fare and service variables were constant. The percentage of annual patronage ranged from 5.68 percent in August to 11.22 percent in January. Analysis of the new patronage data indicates that monthly variations are less pronounced.

The variation in patronage by month, with the sharp peak in winter months, results in capacity deficiencies during peak hours of winter months. There is also a considerable daily variation in ridership, again primarily due to university class schedules with Monday and Wednesday being the peak days. Similarly, there is a considerable variation in transit patronage by time of day with the majority of the transit trips occurring during the peak hours of the morning and evening.

On January 24, 1972, additional peak-hour service was instituted. Headways were reduced from 30 minutes to 20 minutes by adding five buses to each of the five crosstown route pairs. This increased the level of service by one-third during the peak hours of 7:00 to 9:00 a.m. and 4:00 to 6:00 p.m. each weekday.

The monthly patronage for the new system (Table 2) has been increasing in general accordance with the percentages shown in Figure 1. The projections made from the actual September ridership (Table 2) seem to be consistent with the observed ridership. The predictions made from the original revenue estimate (1) are slightly lower than, but also consistent with, the recent data. The original patronage estimates made by the authors (1, pp. 47-51) were obtained from a purpose-specific modal-split model applied to the traffic zones served by each alternative transit plan.

The result of the modal-choice analysis was an estimate of patronage for an average weekday in April, which was approximately 4,300 revenue passengers for the stage-two level of implementation. This could be compared to the weekday average of 4,445 in October and 4,975 in November of 1971.

The important figures for operating purposes are both average weekday and peak-hour ridership. Examination of the patronage data reveals the following:

1. The average weekday patronage has been steadily increasing.
2. The variance in patronage between days of the week has been decreasing.
3. The nature of the peak hour does vary with different days. Mondays, Wednesdays, and Fridays have a "two-pronged" morning and afternoon peak hour that is due to university class schedules. The Friday afternoon peak is much flatter, lasting from 3:30 to 5:30 p.m. Tuesdays and Thursdays have "single" peaks at 7:45 a.m. and 5:00 p.m.
4. Saturday patronage has increased threefold because the lower fare is attractive to youths.
5. Normally, December patronage declines because students are away for 2 weeks. This year patronage did not decline, which indicates that more Christmas shoppers and youths used transit than in prior years.
6. The January patronage was depressed because of capacity deficiencies and "bugs" in instituting the improved service during the last week of January.
7. The February patronage has significantly increased over what was expected because of the improved level of service during peak hours. (February 1972 includes an additional day.)
8. Examination of route-specific patronage is included in a more detailed description of the Iowa City experience (2).

CAPACITY CONTROVERSY

During the fall of 1971, it became apparent that the newly instituted transit service might not be able to handle adequately the peak-hour demand during the winter months of December to March. The question of whether to provide additional capacity during peak hours became a controversial issue. The city administration took the position that adequate service may mean some crowding, delays, and, in some instances, passing people by.

In early December 1971, the question of whether to lease buses to provide additional capacity was considered by the city council. Individuals, including the authors of this paper, and groups such as Citizens for Better Iowa City, Citizens' Advisory Committee to the Area Transportation Study, and Citizens for Environmental Action, pressed for augmenting service. The city manager viewed these efforts to be financially irresponsible and reluctantly provided cost estimates for leasing additional buses based on a 12-month lease and operation. He also produced a revised cost estimate for the existing system, which indicated a larger than budgeted deficit. These estimates painted a projected deficit that the council was unable to assume.

The posture of the city administration changed in January 1972 when the city manager resigned. A new estimate for leasing buses, but for a shorter term, was presented to the city council by the acting city manager. In early January 1972, the city council decided to lease buses to provide 20-minute headways on all routes during peak hours. This action was taken because capacity deficiencies became apparent to all. The additional peak-hour service went into effect on January 24, 1972.

IMPACTS OF NEW SERVICE

The new system was designed to furnish an attractive level of service to the CBD-central campus-hospital complex area from the principal Iowa City residential areas. Origin-destination study data indicate that more than 25 percent of the trips in the Iowa City urbanized area are of this nature. The prior level of service attracted, at most, 3 percent of these trips, whereas the new service continually serves 10 to 12 percent of the daily total and up to 15 percent of the centrally oriented trips occurring during transit service hours.

One of the concomitant effects of the new transit service is a significant reduction in parking revenues. The fall of 1971 saw an increase in the use of the transit system and in the use of bicycles. Table 3 gives the decline in parking revenues for 1971-1972 as compared to the 2 prior years. This decline appears to have been temporary, which indicates it may have been influenced by bicycle users as well as by transit riders. It appears to be too early to draw conclusions. However, this is an important issue because a proposal for a downtown parking ramp is dependent on increased parking revenues that would be achieved by increasing rates.

During November, the new system carried an average of 3.1 revenue passengers per route-mile, generating an average of approximately 46 cents per route-mile in revenue. During the average weekday, the Hawkeye Apartments route generated nearly $1.50 per route-mile, whereas the two lowest patronized routes were about 20 cents per route-mile. On Saturdays, nearly all routes operate at less than half the weekday revenue-producing levels.

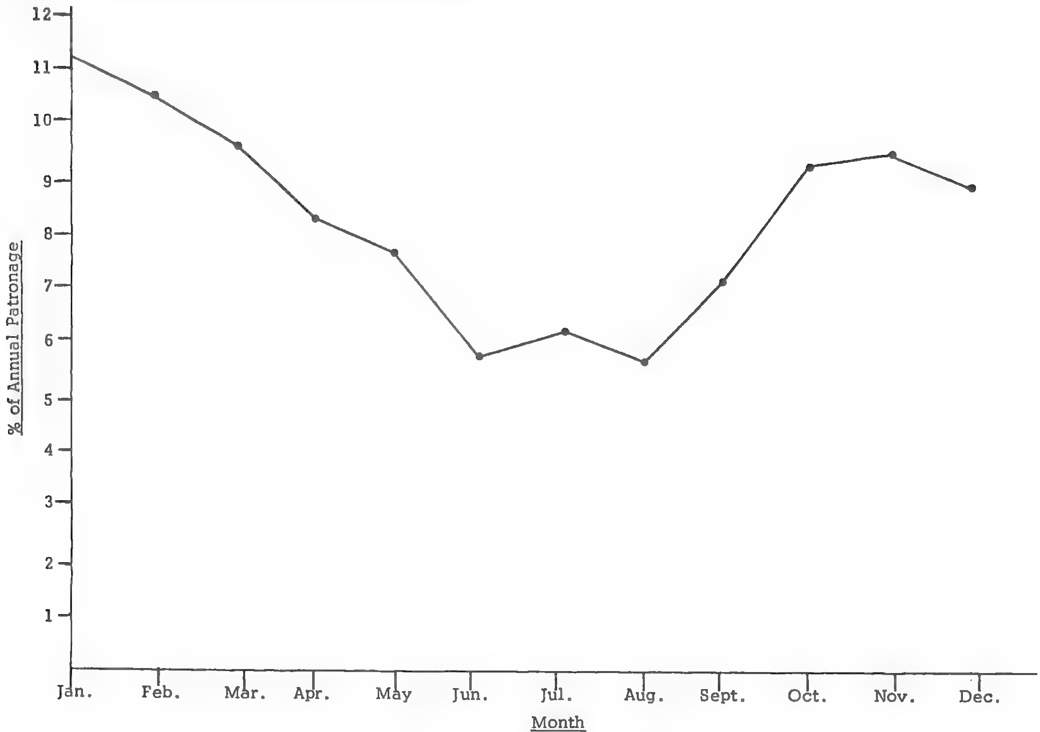
The 15-cent fare has resulted in some fare collection problems, causing an increase in run times and a decrease in driver efficiency. The transit supervisor estimates that more than one-third of all passengers require the driver to make change. A solution would be to sell monthly passes or tokens at a slightly reduced rate. The use of the tokens or a pass would speed up both fare collection and passenger pickup times, allowing the driver to more closely adhere to his schedule, particularly during peak periods.

Generally speaking, transit patronage has increased from about 2,000 patrons per weekday on the old system to about 6,000 patrons per weekday on the new system. What has been the reduction in automobile trips? Parking revenues tell part of the story, and traffic counts, which are not available at this time, may indicate more. If one assumes that one-half of the new patrons formerly drove, a significant reduction in automobile travel has been made.

CONTINUED INVESTIGATIONS

In addition to the continued monitoring of patronage response as previously described, a variety of other studies are under way to continue analysis and improvement of transit service in Iowa City. First, a before-and-after study of transit attitudes and preferences has been conducted and analyzed. Second, a campus travel behavior study has been conducted and is being analyzed. Third, the university has implemented a campus

Figure 1. Percentage of annual patronage by month.



Source: Iowa City Coach Company

Table 1. Fare-patronage relation.

Fare (cents)	Monthly Patronage	Percentage of 25-Cent Standard
10	104,319	193
15	82,023	157
20	66,204	122
25	53,933	100
30	43,907	81

Note: $y_1 = 1{,}252.687 - 54{,}989.547x_1 + 23{,}375.125x_2$; $R = 0.9009$; $R^2 = 0.81$; $SE = 8{,}415$; y_1 = monthly patronage; x_1 = natural log of fare in cents; and x_2 = natural log of University of Iowa enrollment.

Table 2. Revenue passengers.

	Patronage		
Month	Actual	Estimate[a]	Estimate[b]
September	85,540	—	80,000
October	108,540	111,000	104,000
November	109,035	112,000	105,000
December	109,428	105,000	98,000
January	126,851	131,000	123,000
February	136,582	123,000	115,500
Total	—	1,178,000	1,100,000

[a]Based on September 1971 actual patronage.
[b]Based on mass transit technical study projection (1).

Table 3. Parking revenues.

	Type of Parking Revenue[a] (dollars)			
Year	On-Street	Off-Street	Permit	Total
1969-1970	73,370	36,379	8,115	117,864
1970-1971	76,567	39,238	8,750	124,555
1971-1972	68,752	33,719	8,099	110,570

Note: During 1970-1971 and 1971-1972 (September through February), total parking revenues were $146,800 and $134,067 respectively.
[a]Based on September through January period.

shuttle service. Fourth, the Johnson County Regional Planning Commission is applying to UMTA for a long-range transit study to augment the area transportation study being undertaken in the Iowa City urban area with the assistance of the Iowa State Highway Commission.

Before-and-After Study

Just prior to implementing the new transit system, the Institute of Urban and Regional Research conducted the before portion of an attitude and preference study to determine attitudes toward and preferences for transit service. In November, the after portion of the survey was conducted. As part of the survey, travel behavior and socioeconomic data were collected. The surveys were conducted by using a "mail out-mail back" semantic differential type of questionnaire. Scaled responses (agree-disagree) to various statements were used to determine preferences and attitudes regarding transit. In each survey, 500 questionnaires were sent to students and 500 to area residents. In both cases, the return rate was approximately 35 percent. Many persons responding to the first survey agreed to be resurveyed and participated in the after survey.

The analysis determined the effect of variation in some of the significant attributes related to feelings of satisfaction with the new system. Introduction of the new service has increased the total positiveness of people's attitudes toward the transit service. Even those attributes that were unchanged were viewed more positively by respondents. Apparently enough key variables were changed in the transit operation to change the overall image (3).

Campus Travel Behavior Study

A random sample of 3,000 students at the University of Iowa received questionnaires soliciting information about their travel patterns for 1 day. They were asked to respond for the third Monday in May 1971, and approximately one-third of the sample returned completed questionnaires. The returns were checked against the proportion of students by age, sex, and academic major, and the sample agreed closely with the total-universe figures for these variables. Approximately 1,000 usable questionnaires, 5 percent of the student body, were returned. Analysis of the longer intracampus trips and the trips to and from campus are providing clues as to student needs, particularly because students are prohibited from parking in many central campus locations.

The campus travel behavior data have been analyzed and are providing the university's administration with useful information with respect to scheduling classes, locating new buildings, and providing campus transit service. The data will also provide the foundation on which to calibrate a campus travel simulation model (4).

Campus Shuttle Study

The University of Iowa has also entered the field of transportation. Feelings are strong about the proliferation of open parking lots on campus and the use of open space for additional buildings. On the other hand, there is considerable pressure to make more parking space available (within walking distance of the campus) to students and staff. The administration and student senate have instituted a semester-long experimental shuttle bus service around the campus, which serves longer walk trips on campus and a peripheral parking lot.

A circular shuttle route with three buses operating in each direction is being operated during the spring semester of 1972. The student senate and the university administration are providing funding for the system, which uses leased buses and employs student drivers through the work-study program. There is no fare; students and staff only show their university identification. Response to this service is determining the degree to which walking trips are intercepted, the amount of diversion from the municipal bus service, and the utilization of peripheral parking by commuting students and staff.

During the first 6 weeks of operation, patronage has averaged 7,000 passengers per day with a peak day of 8,200. Typically, Monday and Wednesday are peak days during the week although impacts of cold weather are more important. Many long walking trips are diverted to the campus shuttle on cold days. Currently, the impact of warm weather and increased use of bicycles is of concern.

Use of the shuttle has been predominantly by the students and, among the students, chiefly underclassmen. This parallels a tendency for shuttle use to be heaviest among dormitory residents. The average rider uses the shuttle bus about 10 times per week, and about 5,500 different persons use the bus during the course of an average week (with 35,000 ridership). It appears that the bus system is used more in terms of trips with one end at the residence rather than trips around campus. This is because most riders have changed their mode of travel to campus. The most common change is from walking to using the campus bus, but use of the automobile has also been changed such that about 500 automobiles have been eliminated from the central campus. The typical bus passenger is a male, freshman, dormitory resident who uses the bus twice per day to get to class and to return to the dormitory. He would walk if the bus were not available. The nature of the bus use as shown in these data seems to support fairly well the initial objectives of the bus system. It is not only providing a service to those without automobiles, but it is also getting people out of automobiles and getting automobiles off campus.

The university is now exploring ways to make the campus shuttle a permanent feature. Both purchase and lease arrangements are being explored.

Long-Range Transit Planning Study

The mass transit technical study (1) that preceded the new bus system for Iowa City was of a short-range nature. Its emphasis on the short range was primarily due to the need to move rapidly and to the lack of forecasts. Forecasts of population, employment, and travel are now being produced as part of the Iowa City Urban Area Transportation Study. Consequently, it is now possible to conduct a long-range investigation and develop a plan for the long-range transit needs of the Iowa City area. The Institute of Urban and Regional Research hopes to participate in such a long-range transit investigation again as a subcontract to Johnson County Regional Planning Commission, which is responsible for the area transportation study.

CURRENT POLICY QUESTIONS

Even though Iowa City does not suffer so severe a financial plight as most American municipalities, it does not have sufficient funds to use for risk capital to play an active and innovative role in transit. Additional capacity was provided with full knowledge that additional subsidy would be increased. The city could increase patronage by extending the level of service, constructing bus shelters, developing a program to market transit, increasing parking costs, and integrating the transit system with a campus shuttle system to improve distribution. However, increased revenues would not cover the increase in cost, and still more subsidy would be necessary.

What level of service should be provided? This is a key question in Iowa City and is relevant to other public systems that have similar "success." Every time a public system assumes a private operation, the question of extending the level of service must be addressed. If, as in the case of Iowa City, the patronage response is greater than the capacity provided, there will be disagreement as to whether additional service should be provided.

CONCLUSIONS

There are a variety of conclusions that can be drawn from the experience in Iowa City to date. However, Iowa City is unique in that it is a university-dominant city, and the main campus and the CBD are adjacent, which provides an extremely strong central focus that is conducive to being served by transit. This uniqueness, of course, limits the transferability of the experience. Nevertheless, the decline of transit has

been reversed in Iowa City, and it is of interest to determine how this was accomplished. Clearly, the most important factor is the reduced fare, which in itself accounts for an approximate doubling of the patronage in this particular community setting. Students are on extremely limited budgets, and faculty and staff parking permits cost $60 per year. Similarly, the environmental awareness in a university community contributes to some extent to the increased use of both bicycles and buses in Iowa City. At the same time that the bus patronage was increasing rapidly during September and October, there was a substantial increase in the utilization of bicycles. Another factor that may have contributed to the increase in patronage was the wage-price freeze that was in effect when the bus system was instituted. People may have been more rational with respect to out-of-pocket transportation costs than in the past.

Iowa City is now in a position to actively promote transit and to extend its level of service even further if funding can be found. The dilemma is that additional funds to increase the level of service will not generate concomitant revenues. Additional subsidy necessary to increase the level of service is difficult to find because the city originally selected a level of service and a subsidy level in conjunction with budgeting decisions that provide for other necessary municipal services. Consequently, what may happen is that the operation will stagnate at its present level. As costs begin to rise and patronage declines, there will be an increasing pressure to increase fares and thus begin the whole cycle that has defeated transit in the past.

Within the next couple of years, several key policy issues with respect to transit, parking, downtown renewal, streets and highways, and campus planning will be crystallizing. The success of transit in Iowa City and decisions as to its future role will play an important part in these key total transportation policy issues.

Can Iowa City afford more success? Currently, the city attempts to provide service to actual patrons but with increasing subsidy requirements. Substantial increases in service will require a more detailed analysis of benefits to offset the increased subsidy. These kinds of questions are being explored by students in the Urban Mass Transit Administration supported by the University Research and Training Program in Urban Transportation at the University of Iowa. This program has provided a reservoir of talented students to assist the community in analysis of transit issues. Their work has provided both the university and the community with assistance in formulating transit alternatives.

ACKNOWLEDGMENT

This study was supported by the Urban Mass Transportation Administration, U.S. Department of Transportation, Grant No. URT-32.

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A SYSTEMS APPROACH TO SUBAREA TRANSIT SERVICE DESIGN

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The usual transit service design process currently consists of a costly cycle of alternative system designs followed by system testing. A prime deterrent to substitution of optimization techniques is the number and complexity of the parameters that the designer can vary. A partial solution, readily usable with existing analysis programs, is presented. The technique provides a transit-use estimate prior to system design, employing the concept of a ubiquitous transit service in order to avoid prejudicial assumptions as to transit routings. An application involving the design of suburban bus service is described. The technique was used to identify feasible service areas and establish a basic system operating pattern. It was employed in sensitivity analyses to examine alternative fares and service frequencies. The results indicate that the technique has promise as a useful tool in developing improved transit service.

•THE development of structured system design techniques for transit service planning has lagged behind the development of ridership forecasting models. We now have rational and fairly effective means of predicting transit use. Unfortunately little has been done to apply the information gained in forecasting model development to the improvement of design procedures. As a result, we are often better able to evaluate a proposed transit system than we are to design one in the first place.

Paradoxically, it is inherently more important to design efficient and effective transit systems than it is to estimate the ridership with precision. Indeed, good design followed by implementation can be considered as the goal. Good transit-use forecasts, although quite important, are but one of the means to the goal.

The art of transit service design, as now practiced, normally consists of a trial-and-error process of alternative system designs followed by system testing. The process starts by having the system planner investigate the land-use, socioeconomic, and travel-pattern characteristics of the area. With this background information, the planner then proceeds to design transit systems complete with route locations, service frequencies, speeds, and transfer points. The number of alternatives is usually held down by means of policy decisions and design guidelines based on experience. The resultant designs are usually tested by estimating the transit ridership they would attract and by evaluating this in terms of estimated capital and operating costs. In more sophisticated studies, additional tests may be made to measure the increased accessibility provided to specific population groups, particularly the poor.

One of the problems with the present approach is the time and expense involved. If the designs are proved to be inadequate during the testing phase, there is no recourse except to return to the planning phase followed by further testing. Obviously, such a cyclic process, with limited alternatives, inhibits the approach to an optimum system.

A second problem is a lack of knowledge at the start of design as to the amount and nature of transit use possible in the various sectors of the study area. If there is a specific measure available other than that provided by the planner's intuition, it is

Sponsored by Committee on Transportation Systems Design.

generally the product of an earlier design attempt and is thus biased by the earlier design configuration. Obviously, the selection of route location, service frequencies, and even operating techniques and vehicle types should be made in consideration of possible ridership.

Full-fledged optimization techniques for designing transit systems do not appear to be in the offing. A prime deterrent to the development of such programs is the number and complexity of the parameters that the designer can vary. These include transit route location, service frequency, speed, and fares.

This paper describes a partial design solution, the key element of which is the preparation of transit-use estimates prior to system design. These estimates, and measures that can be derived from them, provide a basis for selecting service areas, corridors, frequency of service, and fares. The technique employs the device of using travel forecasting models to test generalized transit service descriptions against the given characteristics of the area under study.

THE DESIGN CONTEXT

Transit System Design Needs

The technique under discussion was developed during the course of a mass transportation study for the North Suburban Transportation Council of the Chicago area (1). The study was done under an Urban Mass Transportation Administration technical studies grant, and technical monitoring was provided by the Chicago Area Transportation Study.

The study area covered the suburban municipalities in the Chicago commuter shed along the North Shore and the Skokie Valley. A major element of the study called for examination of the feasibility of implementing local bus service and development of recommendations on the form such a service should take.

The study area is characterized by medium-to-low population density, relatively easy intrasuburban movement by automobile, and lack of a single dominant shopping and employment area. Excluding the Chicago commuter movement, which is served by fixed-rail mass transit, the remaining travel pattern is quite dispersed.

Normal guidelines were of little use in developing a local transit system plan. Consider the following examples:

1. Route trunk lines along major travel corridors—there are no readily identifiable intrasuburban corridors.
2. Focus the system on the central employment area—there is no dominant high-density employment center.
3. Provide good service to areas of low income—there are no major low-income areas.

Despite the inapplicability of standard design criteria and the existence of conditions not normally associated with high potential transit ridership, the possibility of establishing bus operation was not eliminated. Part of the area currently has bus service. In 1968, the year prior to initiation of the studies, two of the local companies carried 15 percent more passengers than in 1955. For the Evanston Bus Company, the number of revenue passengers carried per vehicle-mile was 15 percent above the national average.

Thus, study-area conditions reinforced the need for a systems approach to transit service design. The task at hand was to design a local bus operation with little assistance from the use of normal criteria for planning bus routes and schedules.

Operating Systems Under Consideration

In the design problem posed by the North Suburban Transportation Council project, bus service had to be designed for two basic categories of local trips. The first category encompassed trips taking place entirely within the suburban area. The second category covered feeder trips between suburban households and the stations of the various Chicago commuter railroad and rapid transit facilities penetrating the area.

In an earlier study phase, available bus technology had been reviewed and the conclusion reached that two principal types of service might have application. One type was conventional bus service, connecting such points of concentration as existed with trunk routes. The second type was pulse-scheduled bus service, a scheme most applicable to low-density areas. A brief description of pulse-scheduled service may be of assistance in understanding the design process under discussion.

Pulse-scheduled bus operation is the system wherein all scheduled buses in a given route set start their routes at the same time and place, circulate around the routes, and return to the starting point in time for each successive periodic cycle. The purpose is to bring all buses together at once to allow transferring with minimum passenger delay and to provide service at intervals that can be easily remembered, such as every 30 min.

Like conventional bus operation, pulse-scheduled operation normally provides service on fixed routes, according to a fixed schedule. However, the schedule, not the route, comes first in the operating hierarchy. The schedule is identical for all routes. Once the schedule is selected, pulse-scheduled routes are designed to fit the operating pattern thus defined.

The pulse-scheduled operating technique is keyed to provide a satisfactory level of service where the total amount of bus riding is relatively low. In a pure example, such as found in some small cities, there are no backbone routes or weak routes. The attempt is made to have each route serve an equal number of the riding population, and all areas receive the same level of service. Although originally conceived for service to a single passenger exchange point, the pulse-scheduled concept can be used with multiple-service nodes. A hypothetical illustration of such an operation is shown in Figure 1.

Consideration of the innovative pulse-scheduled concept necessitated feasibility evaluation of this specific type of service. It was also desired that the systems analysis aid in the selection of passenger exchange nodes for the operation.

THE SYSTEM DESIGN TOOL

Ubiquitous Bus System Concept

The first step in the adopted partial solution to structured systems analysis was to describe a generalized bus service. This was followed by evaluation of the service in terms of study-area travel characteristics. The evaluation included preparation of a transit network description, modal-split estimation, spider network summarization of the resultant ridership forecast, and analysis of sensitivity to varying fares and service frequencies.

The transit-use estimate did not only serve to allow identification of potentially feasible service areas and corridors; it also served as a standard against which to measure the performance of specific systems subsequently designed. The method is analogous to the multiple screenline analysis technique used in highway system design.

The need to describe a generalized transit service having no prejudicial assumptions as to specific routes led to the use of a ubiquitous bus service concept. In essence, it was assumed that the bus service was capable of directly serving each potential transit trip with a single ride from trip origin to trip destination along the shortest available highway route.

Obviously, such transit service cannot normally be provided. The assumption of ubiquity serves only as an aid to systematic analysis. However, it should be noted that only the assumption of ubiquity contradicts the characteristics of regular transit service. The assumption of direct travel without transferring was made in response to the nature of the system being designed, a local operation serving mostly short trips. All other standard transit trip characteristics were made part of the service description, including the following: walk to bus, wait for bus, speed of bus, walk from bus, and fare for ride.

Test System Description

Because there was no route structure, travel along the ubiquitous bus system was described by using minimum paths through the study-area highway network. The average local bus-operating speed of 12.5 mph was used as the running time portion of total travel time. The walk time to the bus was combined with the walk time from the bus and assumed to total 8 min for intrasuburban trips. Walk time for feeder trips to rail service was assumed to total 5 min. These figures were derived from an examination of typical street patterns and assumed service at approximately ½-mile intervals.

A series of average wait times was tested with values ranging from a 7½-min wait for the bus to a 30-min wait.

The fare for the bus ride was computed on the basis of two alternative fare systems. One system assumed a 25-cent base fare that was good for 4 miles of travel, with a 3-cent per mile rate thereafter. The second system assumed a 40-cent fare for the first 4 miles and 5 cents per mile thereafter.

Ridership Estimation Model

Estimation of transit use (assuming the ubiquitous system) was accomplished through application of a trip interchange modal-split model to a person-trip estimate for the study area. The person-trip estimate was derived from forecasts previously prepared by the Chicago Area Transportation Study. The modal-choice model had been calibrated in an earlier work phase (2). The choice model was a simplified version of the type that, for each travel interchange, relates percentage of transit to the difference in trip disutility between automobile and transit (3, 4). The estimating curve is shown in Figure 2.

The trip disutility measure employed in the modal-split model was a function of travel time, convenience, and cost. Highway travel times and costs, including parking charges, were based on current conditions in the study area. Transit service characteristics were those defined by the ubiquitous system description.

It is of technical interest to note that the average computer-time expenditure for each of the six service frequency and fare combinations tested was equivalent to no more than the cost of building one set of transit minimum paths. A modification of the modal-split program from the HUD Transit Planning Programs was employed; it was the provision of a table look-up procedure. To aid in the analysis, trips of less than 4 miles were segregated from longer trips. This was accomplished through use of a special assignment program.

STUDY AREA APPLICATION

Alternative System Parameters

Six different combinations of transit fares and average wait times for the bus were tested in applying the ubiquitous bus system design concept to the North Shore study area. These combinations were as follows:

Class	Base Fare (cents)	Wait (min)
I	25	7½
II	40	7½
III	25	15
IV	40	15
V	25	30
VI	40	30

The testing of these various alternatives allowed analysis of the feasibility of varying service assumptions and provided the basis for the sensitivity analyses.

Service Feasibility Analyses

The initial objective of the service feasibility analyses, as conducted using the ubiquitous bus service design technique, was to identify those sectors and corridors of the study area that could support local bus service. With this determination made, the analyses were next used in the development of a bus route structure.

Table 1 gives the bus-use forecast for the ubiquitous system, considering only local intra-study-area trips. These forecast transit trips were separately assigned to a spider network to produce transit trip estimates by traffic zone and by corridor.

Short transit trip service was investigated for feasibility by comparing the transit trip-end estimates for each traffic zone, and their related revenue-producing capability, to an average bus-operating cost per unit area. This average cost was developed starting with the diagram of a hypothetical pulse-scheduled bus service shown in Figure 1. The service shown requires one bus per fully developed square mile to provide service every 30 min. Assuming approximately 14 hours of weekday operation, including 6 peak hours during which service would be augmented by 50 percent, each square mile requires 17 bus-hours per day. At $8 per bus-hour, the daily operating cost per fully developed square mile is $136.

Feeder trips to the Chicago rail services were estimated separately and included in the revenue-cost comparison for short trips. Figure 3 shows the results in terms of different ranges of ability to meet operating costs with fare-box revenue.

The short-trip class I designation shown in Figure 3 identifies the area where the revenue produced from a 40-cent base fare would cover the operating cost of providing bus service at a 15-min headway. Class II could support routes operating at a 30-min headway, assuming regular scheduling would allow the wait time for the bus to be perceived at no more than a 7½-min average. Class III designates those areas coming within 75 percent of class II requirements.

The major portion of the class I coverage is that part of the study area already supporting fairly extensive bus service. Much of this existing service is even more frequent than the specified 15-min headway.

Long transit trips were analyzed on a mini-corridor basis, again comparing revenue-producing capability and operating costs. No corridors exhibited a capacity for meeting operating costs on the basis of long trips alone. However, the analysis did serve to identify where local bus service could be aligned to serve significant numbers of longer trips. Two degrees of long-trip significance are shown in Figure 3.

By using the results shown in Figure 3 and the details of the analyses, it was possible to make a number of rational design decisions that would not have otherwise been possible prior to specific route design. For example, it was possible to determine that route design should be restricted to the southerly and easterly portions of the study area. It was decided to design a short-trip orientation into the transit operation because the analyses had shown this to be the major potential trip category as pertains to local intrasuburban transit service. Routes were combined to form trunk services along the corridors having large numbers of long trips.

Sensitivity Analyses

As has already been indicated, the results of applying the modal-choice relations in the six ubiquitous system test cases also provided the basis for sensitivity analyses. These analyses investigated the sensitivity of potential study-area transit use to various fares and service frequencies. The findings were then expanded to include investigation of the revenue-cost ratios associated with the different fares and service levels at given trip densities.

The sensitivity analyses were confined to the short-trip forecasts and thus give results that would not be expected from, say, an investigation of long radial routes into a major central business district (CBD). The analyses made use of the daily bus-operating cost per square mile estimate already discussed. The extra cost of providing bus capacity to satisfy demands not met by the basic schedule was not investigated.

Figure 1. Hypothetical pulse-scheduled bus service diagram.

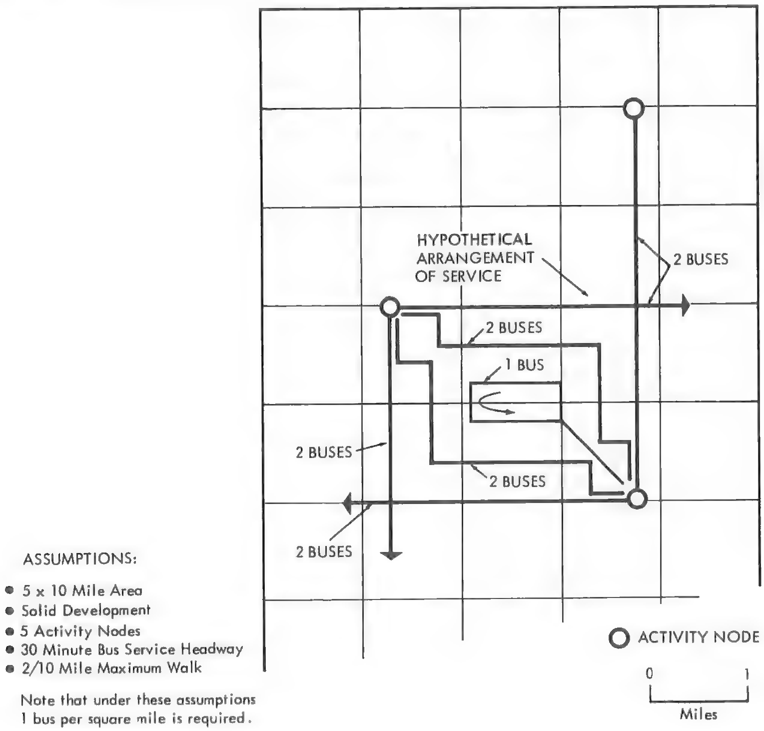


Figure 2. Mode choice estimating curve.

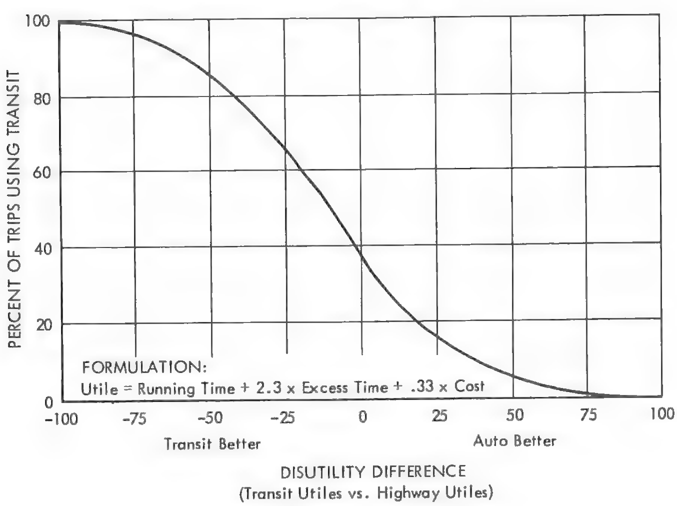


Table 1. Forecast of local-trip bus use.

			Percent Transit		
Class	Headway (min)	Base Fare (cents)	Short Trips	Long Trips	Total
I	15	25	7.8	5.0	6.7
II	15	40	5.9	3.3	5.0
III	30	25	3.0	1.9	2.6
IV	30	40	2.3	1.1	1.9
V	60	25	0.1	—	0.1
IV	60	40	—	—	—

Two alternative sets of assumptions were used in the sensitivity analyses regarding the potential rider's perceived wait time for the bus. For normal bus operation, it was assumed that the average wait would be perceived as being equal to one-half of the bus headway. It was on this basis that the modal-choice model had been calibrated (2). However, analyses were also developed by using the assumption that potential riders might be induced to perceive the average wait as being approximately equal to one-quarter of the headway. This was done because of evidence that the right kind of systematic, easy-to-remember, and well-advertised bus schedule, such as the pulse-scheduled type, might have such an effect. A similar consumer response had been observed in a study-area commuter travel choice of well-publicized and highly dependable commuter railroad schedules.

Figure 4 shows the results of one of the first-order sensitivity analyses. In both parts of the figure, transit use at different base fares is related to the frequency of service provided. The frequency is described in terms of bus headway, the average time interval between buses.

Although transit use is shown as a continuous curve in both parts of Figure 4, it should be understood that the less conservative of the wait-time assumptions is thought valid only when buses are scheduled at even increments of an hour. It should also be noted that the relatively low degree of transit use projected is primarily the result of considering only local trips, in a high-income area, with few significant parking costs and only localized highway congestion.

Although the curves showing the sensitivity of transit use to system parameters are interesting, they do not provide a description of the related feasibility of transit operation. By coupling revenue production and operating cost with the transit-use curves, we can examine the expected revenue-cost ratio in relation to the transit system parameters.

As a preface to reviewing the results, it should be reemphasized that the estimates do not include the extra cost of providing bus capacity to satisfy demands not met by the basic schedules under consideration. The basic schedules tested are adequate at the minimum level of feasibility, i.e., at a revenue-cost ratio in the vicinity of 1. The primary analysis need is thus served. However, revenue-cost ratios that are significantly more than 1 are highly suspect. Capacity analyses and related reestimation of cost would bring these down to a more normal range.

Figure 5 shows the results of examining the revenue-cost ratio for the effect of service frequency. To develop this relation, it was necessary to assume given trip densities representative of the study area. Note that, for the densities used, the optimum headway is 20 min for conventional bus service (perceived wait time is equal to one-half of the headway) and 30 min for pulse-scheduled service (perceived wait time is equal to one-quarter of the headway).

An interesting check on the validity of these results is provided by the detailed data developed in the course of studying transit operation in Tampa, Florida (5). In the Tampa studies, revenue-cost information was developed for each individual bus route. This information is shown plotted against peak-hour service headway (Fig. 6).

Despite the fact that the Tampa system does have a CBD on which to focus and serves a population with a lower average income than the Chicago North Shore, the routes that are serviced less frequently than every 30 min all have a revenue-cost ratio of less than 1. Note that the revenue-cost ratios for routes with 30- and 60-min service headways fall very close to the Chicago results for a 25-cent fare and a perceived wait time equal to one-quarter of the headway. In contrast, the results for Tampa bus routes with headways that are not an even increment of the hour fall lower on the scale.

Unlike the North Shore curves, the Tampa revenue-cost ratios continue to increase for shorter headways. This is because the Tampa data are not stratified by trip density as are the North Shore data.

Figure 7 shows the estimated North Shore revenue-cost ratio sensitivity to transit fares. The sensitivity is less than was the case with service frequency. Note how the curves show that relatively higher fares will be tolerated when better service is provided, i.e., at the shorter headways and perceived wait times.

Figure 3. Service feasibility analysis map.

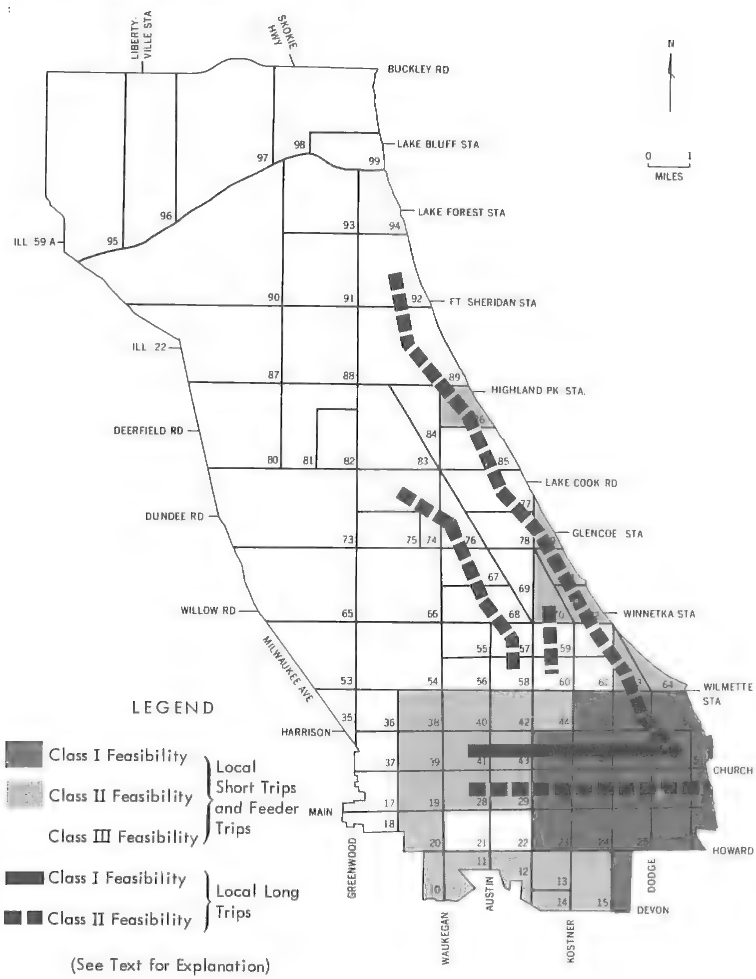


Figure 4. Sensitivity of local bus use to service parameters.

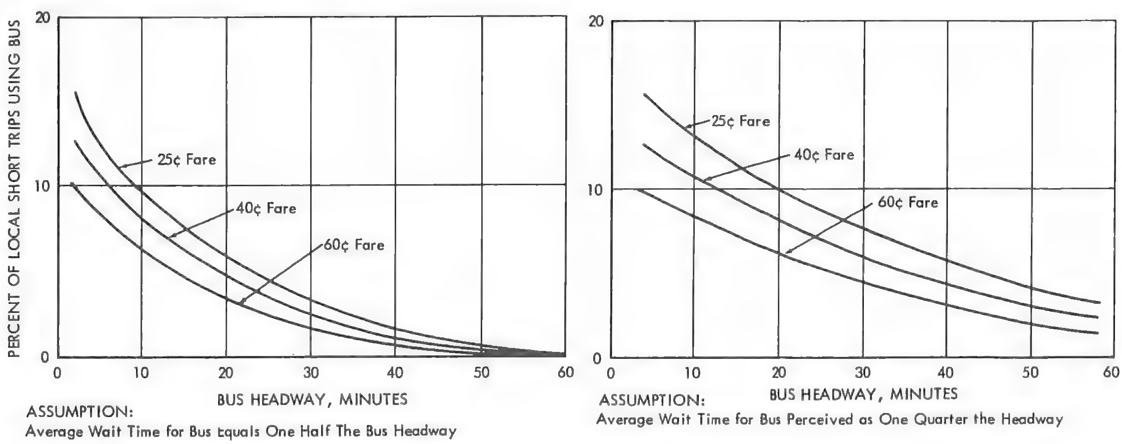
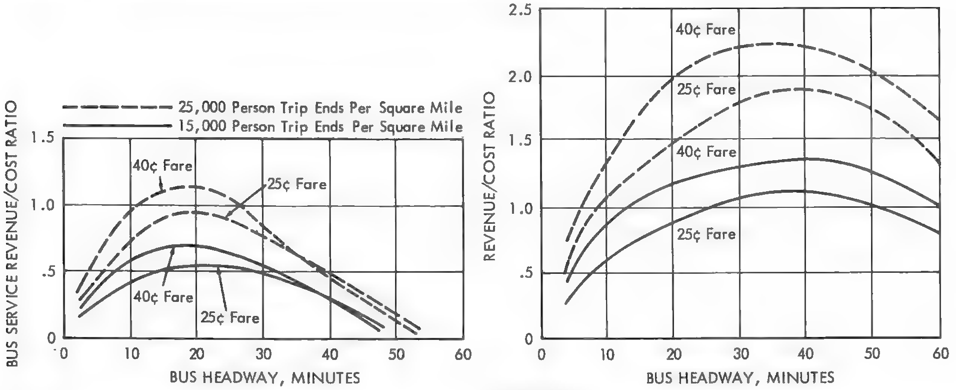


Figure 5. Sensitivity of revenue-cost ratio to service frequency.



ASSUMPTION:
Average Wait Time For Bus Equals One-Half the Headway

ASSUMPTION:
Average Wait Time For Bus Perceived as One-Quarter the Headway

Figure 6. Tampa revenue-cost ratio versus service frequency.

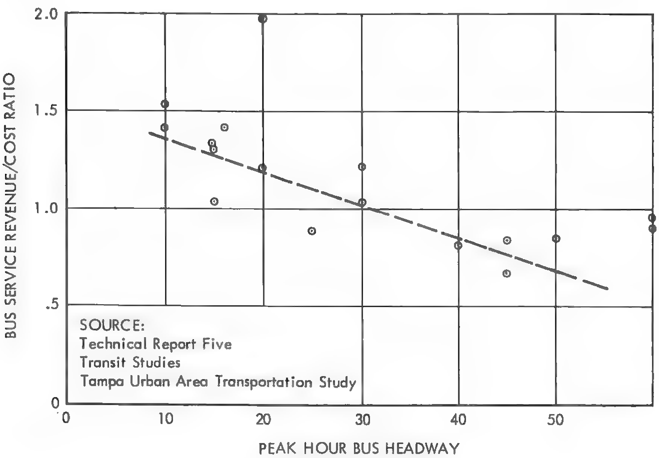
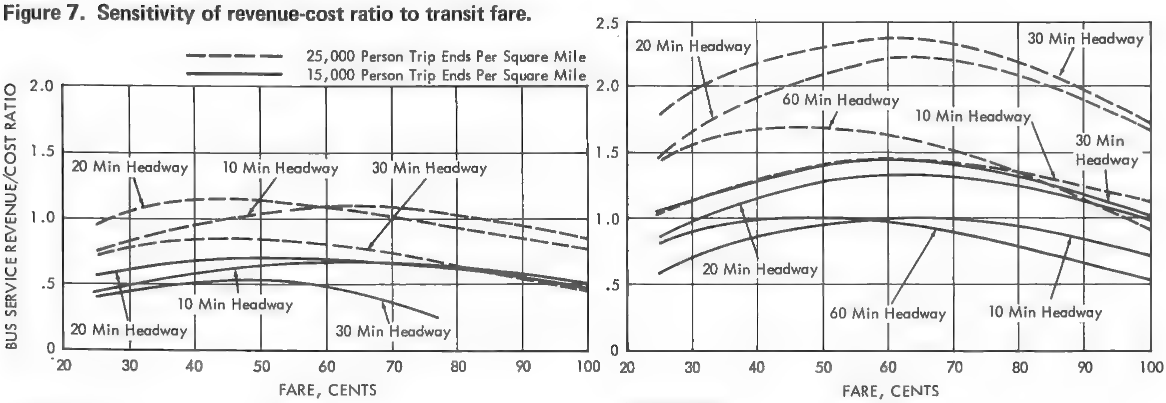


Figure 7. Sensitivity of revenue-cost ratio to transit fare.



ASSUMPTION:
Average Wait Time For Bus Equals One Half the Headway

ASSUMPTION:
Average Wait Time for Bus Perceived as One Quarter the Headway

With the aid of these various sensitivity analyses, and taking into account other factors such as public service implications, we selected fares and service frequencies for the final bus system analysis in the study area. It was decided that no services should be considered that could not support a 30-min headway. Fares were recommended at a 35-cent base rate with a 10-cent zone charge at approximately 3-mile intervals.

System Design Results

The local-service bus system designed by using the ubiquitous system analyses performed quite well when routes and schedules were specified and then tested by application of the travel models. The final test system was planned as having a network of primary trunk routes augmented by a system of supplemental routes on the pulse-scheduled principle. The test system would require approximately 30 percent more buses than are currently deployed in the study area and would serve 63 percent more miles of streets. The ridership projection, based on both local and commuter trip categories, indicated that stabilized present-year use would be 62 percent more than existing study-area bus patronage.

This forecast was derived by using the estimating curves; i.e., the curves provided descriptions of observed reaction of study-area residents to the present bus service. A supplemental projection was made by assuming a perceived wait time equal to one-quarter of the headway for the pulse-scheduled bus services of the plan. With this assumption, total use was estimated to be 115 percent above present ridership.

Using the conservative ridership estimates and a route-specific cost analysis, we forecast that the transit revenues derived from the expanded service would, at 1969 cost levels, pay for 98 percent of the operating cost including depreciation. In light of this finding, the proposed system appears to be practical as well as potentially attractive to study-area trip-makers. It is felt that use of the technique described in this paper contributed substantially to the design.

CONCLUSION

Use of the ubiquitous bus system concept as an aid in planning transit service appears to have many advantages not found in normal design methods. Areas having potential for transit service can be quickly identified. By applying the concept to the sensitivity analyses of transit-operating parameters, we can determine the feasible ranges of fares and headways. The cost of adapting the design concept to computer technology is low when compared with the expense of forecasting use and costs for fully designed alternatives.

Analysis of larger and more complex systems that the example described here would require more detailed assumptions to properly describe a generalized transit service. Varying speed assumptions might need to be employed. It might be necessary to include rules that describe the number of transfers to be encountered for different types and lengths of trips. Specification of existing fixed right-of-way facilities would have to be included. There appears to be no inherent reason, however, why the ubiquitous system concept would not, in some useful fashion, be applicable to most transit service design problems.

The ubiquitous system design technique is, of course, only a partial solution to full system optimization. Nevertheless, it is a first step forward in achieving a structured approach to transit system planning. The results of its application in the example discussed here give promise of its being a useful tool in developing improved transit service.

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